AN INVESTIGATION OF THE MARTEN IN INTERIOR ALASKA

A THESIS

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PREFACE

The marten is one of the four most important fur-bearing animals of Alaska, but despite its economic importance, little is known of the factors affecting its abundance, and consequently its management. This investigation was undertaken to obtain information upon which a sound management policy for the marten might be founded.

Originally this study was divided into two sub-projects: "Population Dynamics and Movements" assigned to the author, and "Habitat Preference and Food Habits" assigned to L. A. Viereck. When Viereck resigned in August, 1952, the author assumed responsibility for the continuation of both projects, for each sub-project was essential to the other. The emphasis of the project, however, remained on "Population Dynamics and Movements".

This investigation was made possible by funds provided by Federal Aid in Wildlife Restoration, Alaska Project 510 W3-R-6 and W3-R-7 through the Cooperative Wildlife Research Unit of the University of Alaska. The investigation was initiated in October, 1951, and was completed in the spring of 1953.

The scientific names of plants used in this thesis follow Hulten (1941-1950). No single source was used for the scientific names of mammals. In the discussion of species mentioned by other authors, the nomenclature they used was followed. Scientific names of Alaskan mammals, however, correspond to those of Rausch (1950).

The author would like to express his sincere appreciation to the many persons who have aided this project in many ways, and without whose help it could not have been completed. It is impossible to list all those who have helped with the project, but those who deserve extra credit and thanks for its completion are listed below:

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Al Lycher, Don Draper, Fabian Carey, and many other trappers, who answered innumerable questions, offered helpful suggestions, and provided carcasses for examination, frequently at the expense of much effort.

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ABSTRACT

An investigation of the marten in interior Alaska.

This investigation of the marten was initiated to obtain information on which to base a sound management policy. Field work on the project was conducted from October, 1951, to April, 1953. The marten's environment, movements, population dynamics, food habits, and management are considered.

In interior Alaska marten are found only in those areas dominated by spruce forest. The two major factors controlling the extent and distribution of spruce are topography and fire.

The results of live-trapping operations and the analysis of sex and age ratios obtained from trapped animals indicated that males and immature animals moved over a greater area than females. Movements may be considerably restricted when food is abundant or in periods of intense cold.

During the season of 1951-1952, 405 pelts and 143 carcasses were examined; in the season of 1952-1953, 641 pelts and 155 carcasses. Sex was most easily determined from skulls on the basis of total length of skull, and from pelts by the presence or absence of the penis scar. Age was determined by measurements of the sagittal crest, the weight of the baculum, and the size of the uterus. No criterion, however, is entirely satisfactory for separating age groups of older animals.

The sex ratio of marten in the harvest of 1951-1952, based on pelts and carcasses was 176:100; in the harvest of 1952-1953, 150:100. The sex ratio of immature animals in the harvest, based only on carcasses, was 103:100, and of mature animals was 138:100. The preponderance of males in the harvest, the differences in the sex ratio of the two seasons, and in the sex ratio of immature and adult animals are thought to be caused by the restricted movements of the adult females as compared to those of males and juvenile females.

Forty-six percent of 1,553 marten from sources other than Alaska were immature. In the Alaskan harvest of 1951-1952, 56 percent of the animals were immature; in 1952-1953, only 36 percent were immature. The low proportion of immature animals present in the harvest of 1952-1953 was probably caused by an unsuccessful breeding season. This unsuccessful breeding season seemed to be reflected by a slight decrease in the harvest.

Marten in the wild appear to be polygamous. The breeding season is in late June or July and parturition is normally in April. The average number of young in litters is approximately three. Sexual maturity is normally attained at age two but in some individuals is delayed until age three. Few animals are thought to be unproductive as a result of old age.

Microtine rodents were found to be the most important food of marten in interior Alaska. Availability, however, seems to be the governing factor in determining the marten's food. Evidence

indicated that food-getting is probably the dominant psychological urge of marten.

Limiting the length of the season seems the best method of harvest control because it not only limits the harvest but furnishes protection to adult females, the most important segment of the breeding population. Statutory refuges are considered impracticable. Management of individual traplines seems the most desirable form of management.

AN INVESTIGATION OF THE MARTEN IN INTERIOR ALASKA

INTRODUCTION

The history of fur-bearing animals in North America is one of relentless pursuit and exploitation. Long before the present century many fur animals were seriously depleted in numbers or even extirpated from much of their original range. Even the vast wilderness areas of Canada and Alaska did not entirely escape the onslaught of the hunter and trapper, although the exploitation of interior Alaska occurred in general at a considerably later date than that of other regions of North America. Early Russian traders to a great extent confined their activities to the coastal and insular regions; Fort Yukon, the only post of the Hudson Bay Company which was founded in Alaska, was not established until 1847.

The gold rush at the beginning of the present century brought hordes of men to Alaska. On the decline of the rush period in the Interior, about 1910, many men without work or claims turned to the harvest of fur animals as a means of livelihood (Alaska Game Commission, 1926). Marten, Martes americana actuosa (Osgood), proved to be one of the fur animals most affected by the added trapping pressure. In 1912 there were about 13,000 marten pelts shipped from Alaska, but in the following years the number of pelts shipped decreased to a low of about 3,000 in 1915 and 1916. In 1917 the season was closed and remained so through 1921. The season was reopened

in 1922 when about 10,400 marten were harvested. Again the annual harvest diminished rapidly and the season had to be closed from 1924 to 1930. Since 1930 the seasons have opened and closed irregularly but with an essentially similar pattern--large harvests following a closed season, a period of declining harvest, and then a closed season. Table 1 records the harvest and the regulation of seasons and limits from 1912 to 1951.

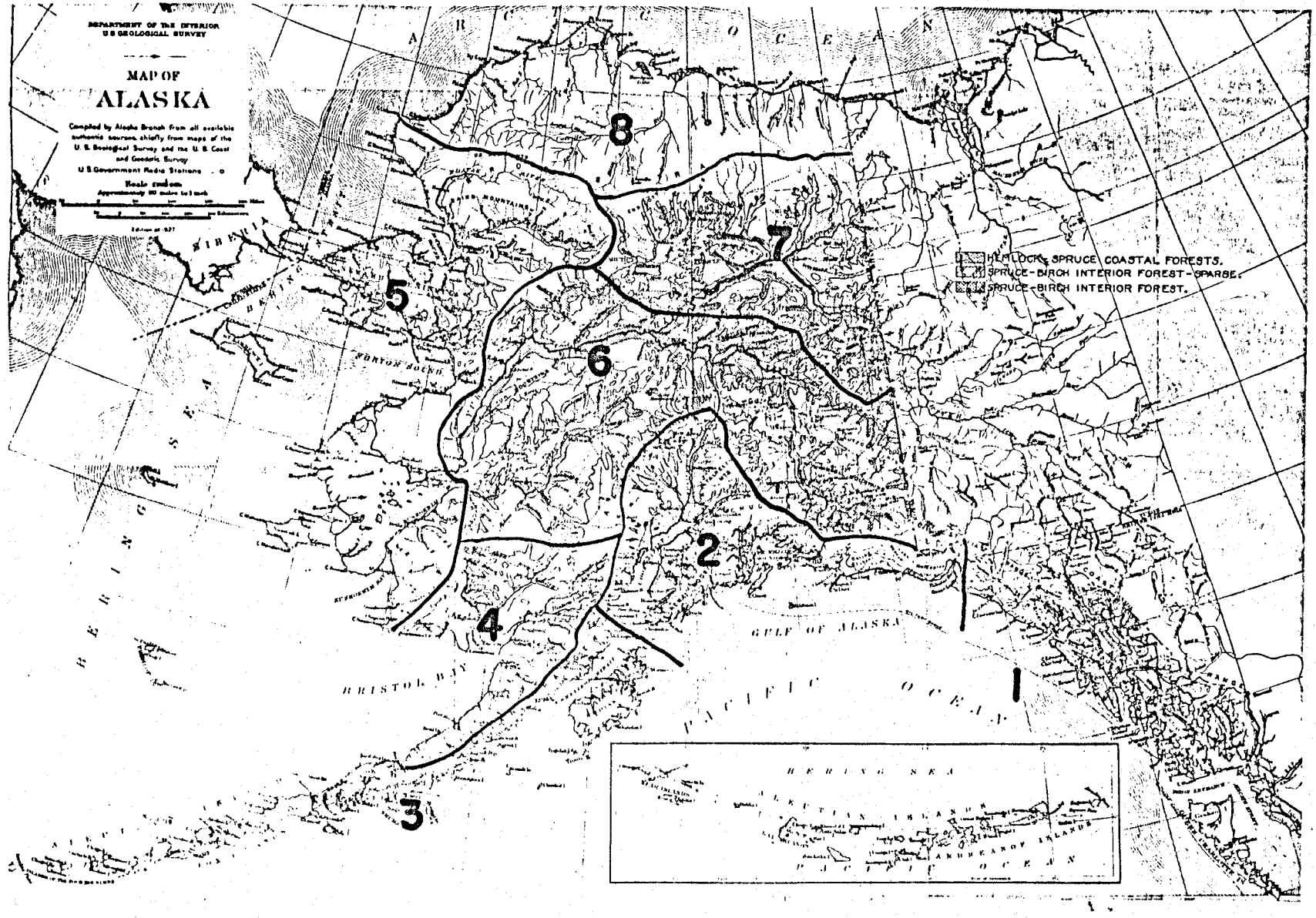
It is instantly apparent on examination of the data that the harvest of marten has not been on a sustained yield basis. Many questions arise. What would be the harvest on a sustained yield basis? Were the long closed seasons necessary? Why was the season closed in 1945 (and some other years) after an excellent harvest the preceding year? Some of these problems will be discussed in following sections. It will suffice to say now that, though the regulations have been conservative and possibly at times unwise, they were perhaps the best that were possible in view of the complete lack of biological information on which to base a better program.

TABLE 1. HARVEST STATISTICS AND REGULATION OF SEASONS FOR MARTEN IN ALASKA FROM 1912 TO 1951

Year	No. Harvested	Seasons and Limits
1911-12	12999	Open season
13	9682	"
14	6497	"
15	3028	"
16	3100	"
17	1210	Closed season.
18	1023	"
19	1107	"
20	123	"
1920-21	676	"
22	10385	Open season.
23	6720	"
24	6019	"
25	3647	"
26	1017	Closed season.
27	342	"
28	0	"
29	0	"
30	0	"
1930-31	7054	Open season. Limit of 10.
32[a]	0	Closed season.
33	4022	Open only in Dist. 7. Limit of 10.
34	4866	Open in Dist. 7 and Tanana drainage.
35	3314	" "
36	1306	Closed season.
37	16969	Open season.
38	9237	Open season except Kenai Pen.
39	1282	Closed season.
40	9626	Open except Dist. 3.
1940-41	707	Closed season.
42	240	"
43	8182	Open except Dist. 3.
44	13352	Open except Dist. 1.
45	453	Closed season.
46	2819	Open only in Dist. 1
47	13413	Open. Limit of 20 in Dist. 1, " " 30 elsewhere.
48	10883	Open except Dists. 1, 8, and Kenai Pen.
49	14141	Open except Dists. 1 and 8.
50	8200	Open except Kenai Pen.
1950-51	9500	Open except Dist. 1 and Kenai Pen.

a/ Eight fur management districts formed (Fig. 1).

Fig. 1. Map of Alaska showing distribution of forest areas and types, and the location of fur management districts.


DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
MAP OF
ALASKA
HEMLOCK-SPRUCE COASTAL FORESTS.
SPRUCE-BIRCH INTERIOR FOREST-SPARSE.
SPRUCE-BIRCH INTERIOR FOREST.
1
2
3
4
5
6
7
8
BERING SEA
GULF OF ALASKA
PACIFIC OCEAN
BRISTOL BAY
ARCTIC OCEAN

THE ENVIRONMENT

Dice (1943) lists four biotic provinces that extend into or are within the boundaries of Alaska: the Eskimoan, Aleutian, Sitkan and Hudsonian. The Eskimoan Province is a treeless tundra underlaid for the most part with permafrost. It is restricted to the area north of the Brooks Range and to a narrow band of coastline along the Bering Sea to the Alaska Peninsula. The Aleutian Province outwardly resembles the Eskimoan, but consists of a heath association outside of the area of permafrost. The Sitkan Province is a dense coastal coniferous forest in Southeastern Alaska; the Hudsonian Province a relatively thin boreal forest corresponding to the Taiga of Siberia. The factors influencing the distribution and characteristics of plant communities in interior Alaska are for all practical purposes synonymous with those defining the Hudsonian Province. They are discussed briefly below.

Climate

Interior Alaska has a continental type of climate with relatively cold winters and warm summers. Temperatures vary throughout much of the Interior between extremes of lower than -70°F. in winter and higher than 90°F. in summer. Fort Yukon, eight miles north of the Arctic Circle, has recorded the coldest temperature (-78°F.) and the warmest temperature (100°F.) so far known for any community in Alaska.

The Alaska Range acts as a barrier to the movement of warm, moisture-laden winds from the Gulf of Alaska into the Interior; consequently annual precipitation is extremely low. Average annual precipitation varies from about 7 to 20 inches and annual snowfall from about 3.5 to 5.5 feet. Effective precipitation, however, is relatively high because of the prevention of runoff by cover plants, because of the low average annual temperature and because of permafrost, which, though discontinuous, covers most of the Interior.

Topography

The Hudsonian Province in Alaska extends through several broadly defined physiographic areas. On the north it is bounded by the southern slope of the Brooks Range and Baird Mountains. On the west it is bounded by a narrow zone of tundra bordering the Bering Sea, a southern extension of the Eskimoan Province. On the south it extends well into the Alaska Range, into the Talkeetna and the Wrangell Mountains, and to the summit of the Coastal Range, but reaches the sea coast only in the vicinity of Cook Inlet. On the east it extends across Canada to the Atlantic Ocean.

Three large river systems, the Yukon, the Tanana and the Kuskokwim, dissect the central valley and plateau of the Interior. Their alluvial floodplains are often wide, poorly drained, and contain many meandering channels, small lakes and bogs. The river valleys are fringed by undulating highlands consisting of much-dissected

plateaus, low ranges of mountains (3,000 to 7,000 feet in elevation) and the foothills of the major mountain ranges.

Soils

Podzols and weakly podzolized soils, interspersed with large areas of bog and subarctic brown forest soils, characterize most of the Interior (Kellogg and Nygard, 1951). Contrary to popular belief, the interior valley was not glaciated during the Pleistocene Epoch although glaciers did exist in most mountainous areas of the region. This lack of glaciation has considerably influenced the origin and character of the parent material, which consists largely of alluvium or loess. Thick gravel deposits, however, occur in glaciated areas. The presence of permafrost profoundly influences the development of soil and characteristics of the vegetation.

Vegetation

A thin, climax, boreal forest consisting of white spruce, Picea glauca (Moench) Voss, and black spruce, Picea mariana (Mill.) Britt., Stern and Pogg, characterizes the vegetation below timberline. Birch, Betula resinifera Britt., and Betula kenaica Evans, on uplands or well-drained sites, and larch, Larix laricina (Du Roi), K. Koch., on poorly drained sites, may at times be associated with the spruce. Birch, aspen, Populus tremuloides Michx, and balsam poplar, Populus tacamahacca Mill., are common in seral stages, especially on moderately or well-drained sites. Willow, Salix spp.,

alder, Alnus crispa (Ait.) Pursh and Alnus incana (L.) Moench, and dwarf birch, Betula nana exilis Sukatch., and Betula glandulosa Michx., are especially abundant as seral stages near or above timberline and in poorly drained sites, although they may also occur as an understory in the mature forest. Other important shrubs of the understory are Labrador tea, Ledum palustre subsp. groenlandicum (Oeder) Hult., and Ledum palustre L. var. decumbens Ait., Hort. Kew., low bush cranberry, Vaccinium Vitis-idaea L. var. minus (Lodd.) Hult., blueberry, Vaccinium uliginosum L., crowberry, Empetrum nigrum L., cloudberry, Rubus Chamaemorus L., nagoonberry, Rubus arcticus L., cranberry, Oxycoccus microcarpus Turzc. ex Rupr and bog rosemary, Andromeda polifolia L.

Sphagnum moss, Sphagnum spp., is the most abundant ground cover--with or without an accompanying growth of lichens, Cetraria spp., Cladonia spp. and many others. In black spruce stands it often forms a thick mat, covering the ground in uplands as well as in lowlands. Horse tail, Equisetum spp., sedge, Carex spp., and cotton grass, Eriophorum callithrix Cham., are also common.

In interior Alaska marten occur only in those areas dominated by spruce forest, which is apparently the basic element in their habitat. Hence the extent and distribution of the spruce must enter prominently into any study of the marten. Primary factors which seem to control the distribution of spruce (within the limits of those defining the biotic province) are physiography and fire.

Lutz (1950) describes black spruce as a physiographic climax and white spruce as the climatic climax, although from the standpoint of stability he regards them as equal. As black spruce is normally more tolerant of cold or of inadequate drainage than is white spruce, it usually dominates in stands near timberline (Fig. 2, 3, 4 and 5). White spruce occurs primarily along streams and on well-drained slopes (Fig. 6).

Forest growth near timberline is often marginal and summits of most hills and ridges above 2,000 feet are barren of trees, though as hills increase in height timberline on the sheltered slopes and ravines approaches an altitude of 3,500 feet or more. Topographic conditions are such that a great proportion of interior Alaska is about the elevation of timberline. This condition results in an interdigitation of forest and tundra or of forest stands of varying density in stands near timberline.

In the last half century fire has destroyed an estimated 80 percent of the original stand of white spruce in Alaska, and an average of about a million acres burns annually (Lutz, 1950.). It is inevitable that considerable change results in vegetative patterns as an aftermath of fire. The degree of change that results depends on the composition of the original stand and the extent and severity of the fire.

Black spruce, normally growing on sites unfavorable for the growth of other tree species, usually succeeds itself after fire has

destroyed the mature stand. Single, light fires do not always destroy stands of white spruce but do create openings for the invasions of species such as aspen or birch. White spruce is destroyed by severe fires. Replacement of white spruce after fire is usually by aspen, birch or other sub-climax species. In mixed stands, black spruce, because of the resistance of its cones to damage by fire, provides a ready source of seed and may often replace the white spruce. Repeated fires may reduce the forest to a treeless condition for long periods.

The total effect of fire on wildlife is not yet fully understood. Any fire, however, tends to reduce the value of the burned area to wildlife for many years. Some fires may in time produce "moose pastures" by changing the climax to a seral stage more suitable for browsing, but at the same time may destroy lichens which are needed by caribou and eliminate fur-bearers such as the marten, to which the climax spruce forest seems essential.

Fig. 2. Spruce forest area on the Dennison River Fur Animal Refuge.

Fig. 3. Growth pattern of spruce forest near timberline on the Dennison River Fur Animal Refuge. Conditions for forest growth are suitable only on the warmer, south-facing slope.

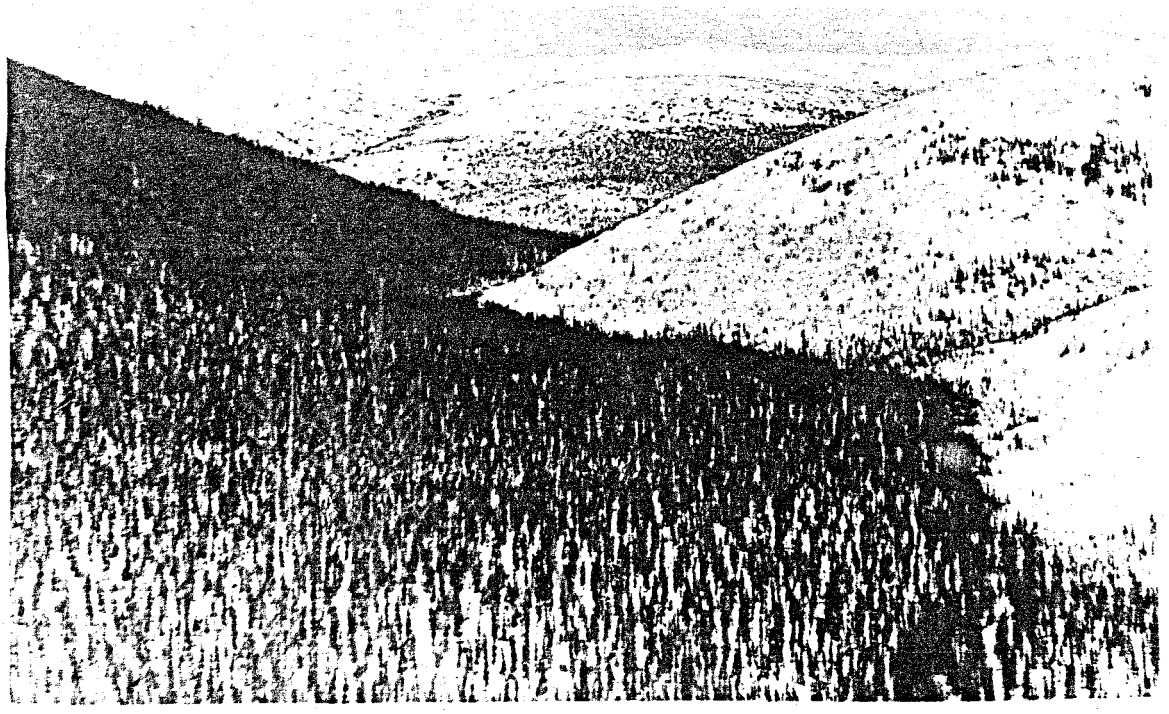


Fig. 4. Cassiar Valley at 55 mile on the Steese Highway.

Fig. 5. North-facing slope of Cassiar Valley. Note the drainage pattern and its relationship to the distribution of spruce.

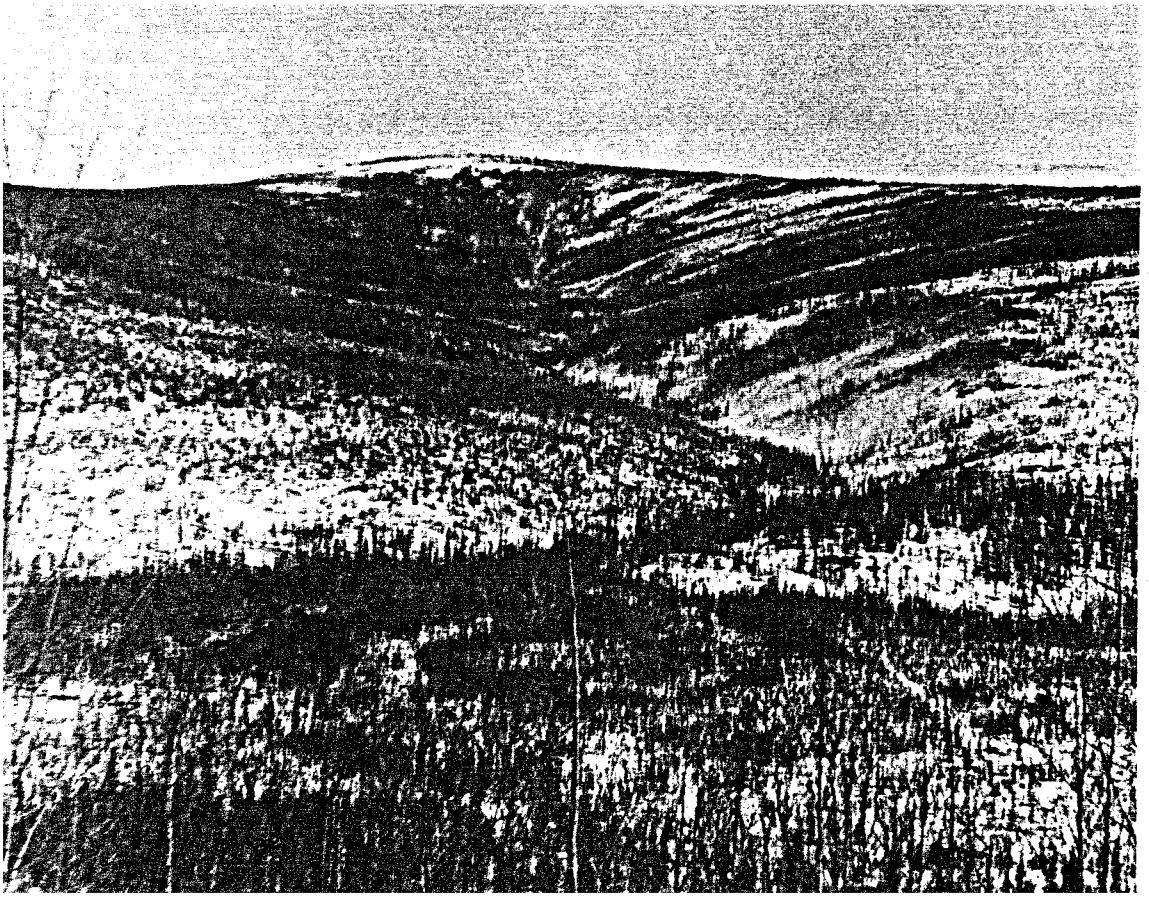


Fig. 6. White spruce growing on the well drained banks and islands of Herron River near Castle Rocks.

Fig. 7. Black spruce growing around a small filled in lake near Castle Rocks.

POPULATION DYNAMICS

Animal populations are subject to constant change. The character of the variation, whether in total numbers of individuals or in the structure or composition of elements within the population, is dependent on two primary factors: (1) the reproductive potential, or theoretical maximum rate of increase when all factors are optimum; and (2) the environmental resistance, or all those factors which tend to suppress or retard the growth of a population. Because the reproductive potential is a theoretical constant for a given species and is seldom even approximated under natural conditions, the term ecological potential (partial potential of Allee et al., 1950) is used to designate the reproduction possible with a given set of environmental factors. Thus there is an inverse relationship between the ecological potential and the environmental resistance.

Methods

The factors involved in the control of a marten population are not all known and those that are known are not fully understood. Those that are even partially understood are difficult to evaluate.

Census, usually the first requirement in the analysis of a population, poses an all but insurmountable task, for observations of marten in the wild are relatively rare. Marshall (1942), Thompson (1950), and De Vos (1952) have suggested track counts in the snow as an index to the population level, but in each case with many

reservations. Newby (1951) located his populations of highest density in summer months by the relative abundance of scats along trails.

In the present investigation, no attempt was made to census marten, though the procedures mentioned were used as an aid in the selection of live-trapping sites. Relative annual population figures were obtained from trapping statistics.

Information on reproduction of the marten was obtained largely from published and unpublished records of ranched animals. These figures were supplemented by the examination of carcasses and pelts, and by the examination of 36 live-trapped animals.

The determination of the composition of wild populations proved to be a complex problem. Sex and age ratios were obtained from the examination of several hundred pelts and carcasses, but figures obtained in this way may differ considerably from true values because trapping methods are selective for particular sex and age groups. Procedures for determination of sex and age of marten from carcasses and pelts are discussed below.

Sex and age determination.--Methods for determination of the sex and age of various fur-bearers by examination of pelts or carcasses are described in the literature, but few methods can be applied directly to the marten in Alaska. Modifications, however, are usually possible. The techniques used with most success are described below. In many instances they have proved inadequate,

but refinement or change necessarily awaits the gathering of additional comparative material, especially from animals of known sex and age.

Sex and age determination from pelts.--Pelts provide an accurate source of information on sex ratios of trapped animals and may also provide a limited amount of information on age structure of the population as well. The value in obtaining such information from pelts rather than from other sources is that the techniques involved are simple and rapid and that comparatively large numbers of pelts can be examined at local fur traders with a minimum of effort.

Sex determination.--The sex of marten pelts can be determined with considerable accuracy merely by noting the general appearance of the pelt, its relative size, the texture of the fur, and the thickness or "feel" of the leather. The most accurate method of determining sex, however, is by noting the lie of the underfur at the posterior end of the abdominal gland (Lampio, 1951).

The penis scar may be seen readily on the pelts of most carnivores that are case-skinned, though on marten, which are dried fur side out, it is often difficult to see. Its presence, however, can usually be detected by feeling inside the pelt at its approximate location for the site of the scar is usually hardened and somewhat thicker than the rest of the pelt. In any questionable case, the sex can be easily verified from the direction of growth of the underfur at the

posterior end of the abdominal gland (the site of the penis scar on males). In females the underfur continues to grow in a posterior direction, but in the male it grows anteriorly at the site of the penis opening.

In the examination of pelts during the 1951-1952 trapping season, nearly all pelts handled were measured. These measurements included body length, tail length, foot length, total length to end of hind foot, width of pelt at forelegs, and the length of the abdominal gland. Distinct differences in size between the sexes appeared in nearly all measurements. The difference between the sexes, however, was often exceeded by variations caused by the manner of stretching or preparing pelts used by the different trappers and measurements are, therefore, of limited use except on a qualitative basis. The minimum, mean, mode, and maximum values of the most important measurements are summarized in Table 2.

Age determination.--There are no satisfactory means of determining the age of marten from pelts. It may be possible, however, to identify females which have previously borne a litter by the presence of raised nipples, which can be felt through the fur as described by Petrides (1950). The validity of this method is as yet open to considerable question because results obtained from it do not compare favorably with those obtained from carcasses.

TABLE 2. SUMMARY OF MEASUREMENTS OF MARTEN PELTS

	Length in Centimeters									
	Foot		Body		TOTAL		Body + Leg		Abdominal Gland	
	m	f	m	f	m	f	m	f	m	f
Minimum	7.1	6.5	50	46	68	63	65	60	6.0	4.0
Maximum	9.5	8.3	69	61	89	85[a]	90	83	9.5	8.0
Mean	8.2	7.3	60	53	79	71	78	64	7.5	6.3
Mode	8.0	6.8	61	53	80	70	80	72	7.0	6.0
Sample Size	44	24	133	61	191	102	239	134	51	24

a/ Much larger than any other female.

Sex and age determination from carcasses.--Carcasses obtained from trappers during open seasons may provide valuable information on sex and age composition of the population, on food habits, on diseases and parasites, and on reproduction. The carcasses examined represent only a small percentage of the total harvest, because their collection often entails considerable inconvenience to the trapper and presents acute transportation problems. To overcome these difficulties, many trappers were asked to save only the heads, for sex and age can be determined from the skull. If only the heads are saved, a greater volume of information on sex and age composition is obtained than would otherwise be possible, though some other data are lost.

When possible, trappers were contacted personally, but many were reached only by letter or by means of publicity given the project over the radio. In the former instance, trappers were supplied with tags to mark the carcasses or heads so that the date of capture and the sex of the animals could be known.

Sex determination.--Determination of sex presented a problem in those instances where only the heads were saved. Examination of skulls from marten of known sex showed that although the sexes could be separated visually with almost complete accuracy, few methods involving measurements allowed statistical demonstration.

Sex determination depends on the marked difference in size of the sexes in a given age class. A rough separation of first year males and first and second year females on the basis of the presence or absence of a sagittal crest was usually a sufficient age class distinction, though measurements of some aged females overlap measurements of some crested males.

The most satisfactory measurement for the separation of sexes is the total length of the skull. In a sample of 104 skulls, no skull of a juvenile female exceeded a length of 80 mm., or no adult female's a length of 82 mm. (Fig. 10). There was no male skull less than 83 mm. long; thus, complete separation of sexes on the basis of total length was possible. A decided advantage of this measurement over any other except the zygomatic breadth is that it can be obtained with

sufficient accuracy from an uncleaned skull.

In the use of zygomatic breadth as a criterion of sex, skulls with a breadth of 45 mm. or more were considered males. On this basis, 18 out of 213 skulls were incorrectly classified. Error was primarily among those classified as juvenile males among which 3 of 31, or 10 percent of the skulls, were sexed incorrectly, and in adult females among which 13 of 49, or 25 percent, were sexed incorrectly (Fig. 10).

Where sex ratios are near 100:100, errors are compensatory --that is, incorrect sexing of males is balanced by similar error in sexing of females. Thus, sex ratios obtained on the basis of the measurements are more accurate than at first seems possible. For instance, in sexing 213 marten by the use of zygomatic breadth, 8.5 percent were sexed incorrectly but the final calculated sex ratio erred by only 1 percent. In the use of condylo-basal length as a criterion of sex, in a sample of 290 skulls where measurements which exceeded 80 mm. were considered males, 4.7 percent were sexed incorrectly but the computed sex ratio was only 2 percent in error.

Age determination. --Several methods attempting to establish age criteria for mammals involve measurements which show polymodal distribution when plotted as frequency polygons or histograms. The success of most of the methods depends on a continual growth of the individual animal throughout its life span, and upon the

homogeneity, especially with respect to size, of the individuals of the same age in the population. The marten meets neither of these requirements fully, for adult size is attained in a few months and relatively little growth takes place thereafter. Though slight growth is evident, particularly in the skull, individual variation often exceeds differences between age classes. Thus, when measurements of total length, condylo-basal length, interorbital breadth and zygomatic breadth were plotted, they formed normal to platykurtic or very weakly bimodal curves. In the graphing of measurements related to crest and bacula, however, strongly polymodal curves are produced (Fig. 11). The results are quite similar to those described for marten, Martes caurina caurina (Merriam), in Montana by Marshall (1951).

Both the sagittal crest and the bacula grow comparatively large amounts in an otherwise grown individual. In young marten, the temporal muscles originate laterally on the parietals. Gradually, however, the lines of origin move toward the mid-dorsal part of the cranium, where they eventually meet--first posteriorly and then gradually anteriorly. At their juncture, ossification is apparently continuous and results in the formation of a ridge, the sagittal crest, between the temporals.

Because of the unique formation of the sagittal crest, three series of measurements related to its development show possibilities as criteria of age: 1) the distance separating the temporal

muscles, which even on a cleaned skull may be observed by faint ridges (temporal crests) which are deposited at the origin of the muscles; 2) the length of the crest; and, 3) the height of the crest. The distance between the temporal crests or muscles proved the least satisfactory of the three methods, though it is the only convenient method of separating females of less than one year old from females between one and two years old. Of the remaining measurements, the height of the sagittal crest seemed most sensitive to age, and showed greatest correlation with weight of the bacula. Disadvantages of this measurement, however, are readily apparent. The height of the crest (actually a misnomer) is obtained by measuring the distance from the upper surface of the foramen magnum to the top of the crest. Although this measurement may be obtained with consistent accuracy, it requires careful standardization of procedure; two observers are almost certain to obtain slightly different measurements. Another disadvantage is that the method requires the cleaning of flesh from the skulls. Because of these disadvantages, this measurement is not recommended for general field use, although it may be used with advantage in comparison with, or as a check on, other criteria of age.

The length of the sagittal crest is the best criterion of age for general use. It appears to be fairly reliable, especially in the first three years, and allows both ease and precision in its measurement.

The characteristics of the bacula of several mustelids were discussed as early as 1909 by Pohl, who suggested their use in taxonomy and noted variation of bacula from immature and mature animals. Popov (1943) also pointed out the contrast, both in appearance and weight, of the immature and adult bacula of six different mustelids and demonstrated their value as a criterion of age in the analysis of the ermine populations in Tartaria for a period of 12 years. More recently, Marshall (1951) has demonstrated the use of the bacula as an age criterion in marten; Elder (1951) in the mink, Mustela vison Schreber; and Wright (1950) in the long-tailed weasel, Mustela frenata oribasa (Bangs). Only Wright, however, has clearly indicated the characteristics of the bacula's development which make it particularly useful as a criterion of age. Noting the sharp distinction between the bacula of immature and mature weasels, he thought it likely that the growth was stimulated by the increased production of androgens during the breeding season. To test this theory he castrated several immature animals and found that these animals did not develop bacula characteristic of adult animals. To conclude the experiment, he implanted pellets of testosterone propionate in castrated males, after which the bacula grew to adult size. Bacula of adult animals which were castrated showed no regression after castration.

A similar delay in the development of the bacula to that in the weasel is apparent in the marten, although in the marten the first breeding season of the male does not occur until after it is two years

of age. The weights of bacula of immature characteristics, when plotted as a frequency distribution, fall into a more or less normal curve between weights of 70 and 130 mg. Measurements of the length of the sagittal crests of the same animals from which the bacula were obtained, indicate clearly that two age groups are involved: 1) those in which the sagittal crest has not yet developed; and 2) those in which the sagittal crest varies from about 3 to 20 mm. (Fig. 11).

Methods of age determination of females are similar to those for males, though individual measurements may differ somewhat because of the smaller size of the female. In addition, the development of the crest in the female is quite retarded as compared with its development in the male. This characteristic has been noted also in the European spruce marten, Martes martes L., by Jacobi, whom Schmidt (1943) quotes as follows:

> . . . the skull comb of the male developed immediately after the second dentition was complete and then grew higher and higher until the animal died a natural death. In a female of the same age the bone ridge is barely indicated, for it grows quite slowly and even when most strongly developed, remains far behind the male.

Marshall (1951) notes a similar situation in the skulls of American marten. It is not, however, nearly so marked a variation as described by Jacobi.

In spite of the retarded development of the sagittal crest in females, it is still the best criterion of age. No measurement, such as the weight of the baculum for males, has proved entirely

satisfactory for use in comparison with the crest to test reliability. Mature females, however, may be separated from immature females with considerable reliability by the presence of corpora lutea in the ovary and by the enlargement of the uterine horns. Since all females do not reach maturity at the same age, separation of exact chronological ages is not possible, but only a separation of relative or physiological ages.

Measurements of the sagittal crests of females fall into three sharply defined groups (Table 4 and Fig. 11); 1) those in which the crest is not yet developed; 2) those with a crest length of 1 to 25 mm.; and 3) those with a crest length of more than 25 mm. (Figs. 9 and 11). Measurements of the minimum separation of the temporal crests of animals in which the sagittal crest is not yet developed indicate that two classes are involved--animals whose temporal crests are separated by 5 mm. or more being in the first year class, and those whose crests are separated by less than 5 mm. in the second year class.

None of the females in the first two year classes was sexually mature. Marshall (1951) suggested that the lack of a crest until the age of sexual maturity in the female (normally the third year), and the sharp peak in a frequency distribution of crest length at 4.0 to 8.0 mm. immediately after maturity, may indicate that the sagittal crest is a secondary sexual characteristic. This possibility, however, does not seem to be true, or if so, only to a slight degree, for the gradual encroachment of the temporal crests on one another between the first

and the second year, if continued at the same rate until maturity would result in a short crest such as actually occurs. Continuation of the growth may also account for the sharp differentiation between three- and four-year old animals. By the time the female marten is four years old, however, the temporal muscles have joined for a great proportion of their total length, and the relatively slight elongation of the crest which takes place after that age is masked to a considerable extent by individual variation of the animals. (Figs. 8 and 9)

In addition to the criteria of age which have been discussed, several qualitative criteria are of some value. The general increase in massiveness of the skull, the closure of sutures (especially between the nasals), the overall ossification, and the marked ossification of particular areas on the skull such as the lambdoidal crests, point to the greater age of certain individuals. These criteria are particularly useful in the analysis of the older age classes, in which individual variation causes overlapping of measurements in criteria which were valid in younger age classes.

Measurements and characteristics which apply to each age classification are summarized in Tables 3 and 4. These criteria are based entirely on animals of unknown age. The criteria separating mature from immature animals, and those separating females in their third year from older animals, are probably highly reliable. Criteria for separation of age classes of older animals, however, should be used only with extreme caution. Although collection of

TABLE 3. CRITERIA FOR DETERMINING THE AGE OF MALE MARTEN

Age	Weight of Bacula in mg.	Height of Sagittal Crest in mm.	Length of Sagittal Crest in mm.
0-1	less than 130	0	0
1-2	130-205	less than 16	1-20
2-3	206-260	16-19	25-40
over 4	more than 260	more than 18	41-50
over 5	more than 260	more than 18	more than 45

TABLE 4. CRITERIA FOR DETERMINING THE AGE OF FEMALE MARTEN

Age	Length of Sagittal Crest in mm.	Height of Sagittal Crest in mm.	Minimum Separation of Temporal Muscles in mm.
0-1	0	0	more than 5
1-2	0	0	less than 5
2-3	1-20		0
3-4	25-37		0
over 5	more than 38		0

Fig. 8. Skulls and bacula of male marten showing variation in different age classes. Scale 1:1. Skulls from left to right are tentatively aged at: 4 or 5 years and possibly older, 2 to 3 years, 21 months, and 9 months.

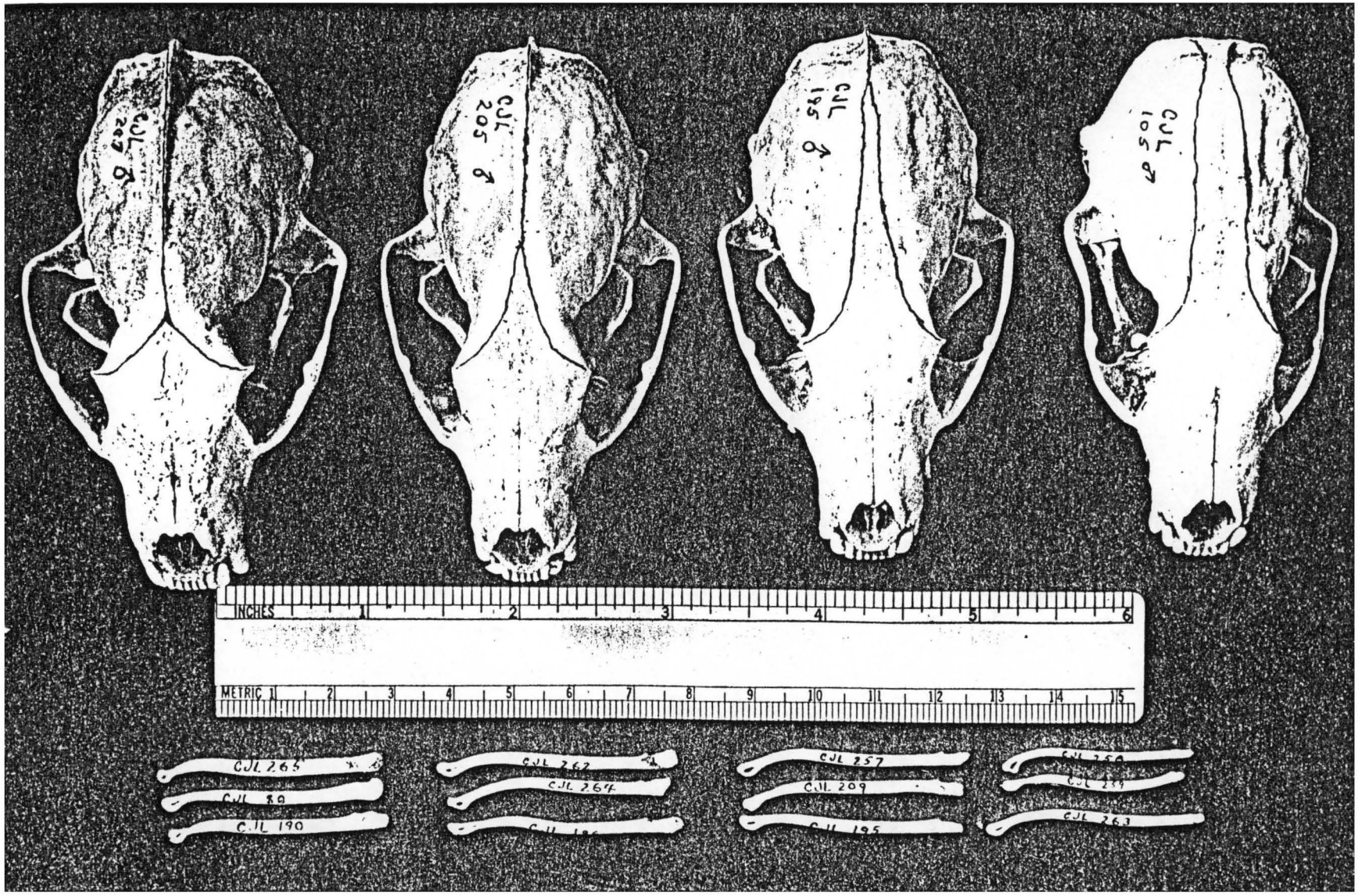

CJL 206 ♂
CJL 205 ♂
CJL 195 ♂
CJL 105 ♂
INCHES 1 2 3 4 5 6
METRIC 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
CJL 265
CJL 89
CJL 190
CJL 262
CJL 264
CJL 257
CJL 209
CJL 195
CJL 260
CJL 259
CJL 263

Fig. 9. Skulls of female marten showing variation in different age classes. Note lesser size and the lesser ossification of the sagittal and lambdoidal crests as compared with that of males . Skulls from left to right are tentatively aged at: 3 to 4 years or older; 33 months, 21 months, and 9 months.

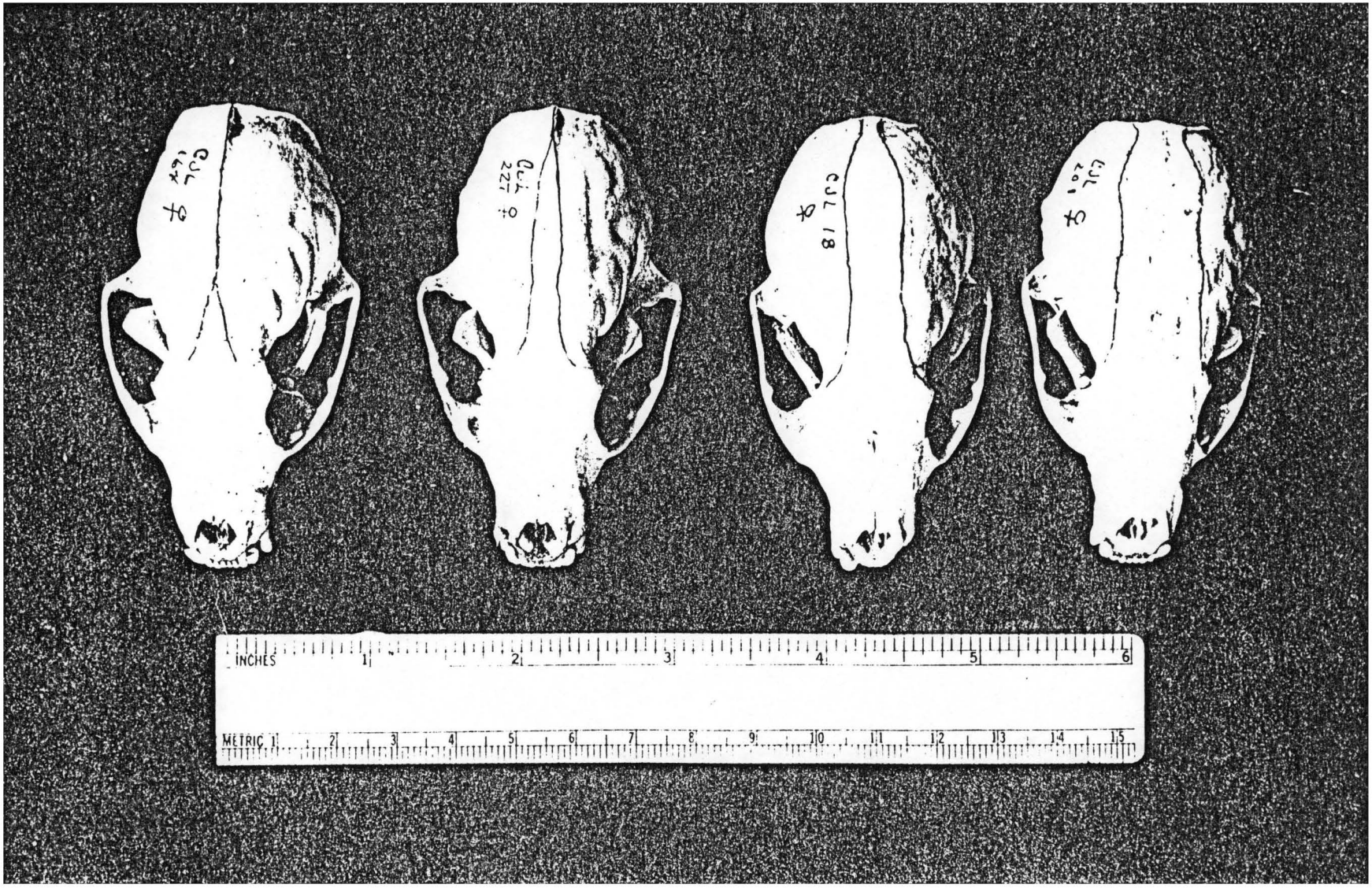

INCHES
1
2
3
4
5
6
METRIC
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Fig. 10. Frequency polygons of zygomatic breadth and skull length measurements to show separation of sexes.
A. Animals without a sagittal crest.
B. Animals with a sagittal crest.

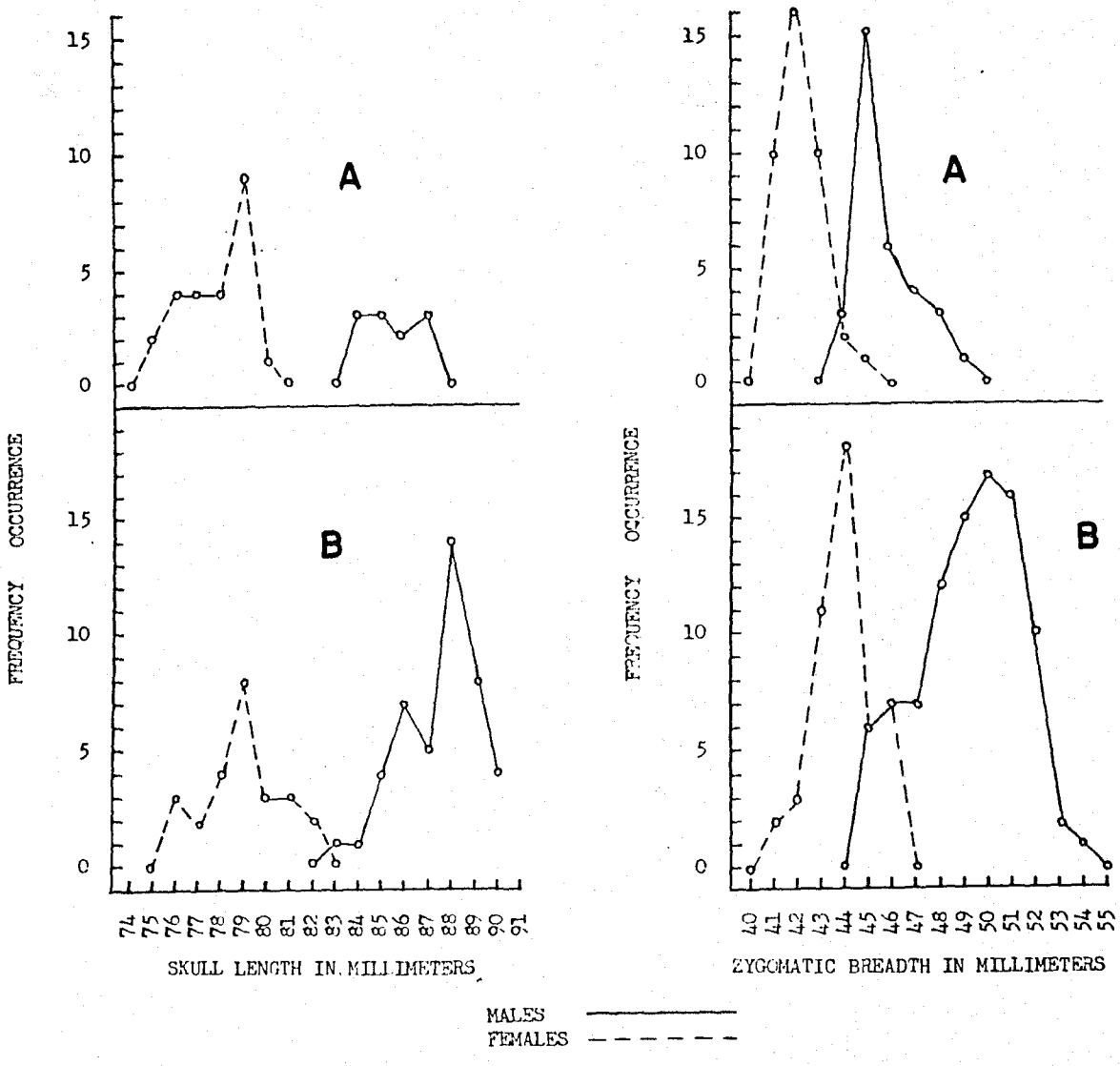
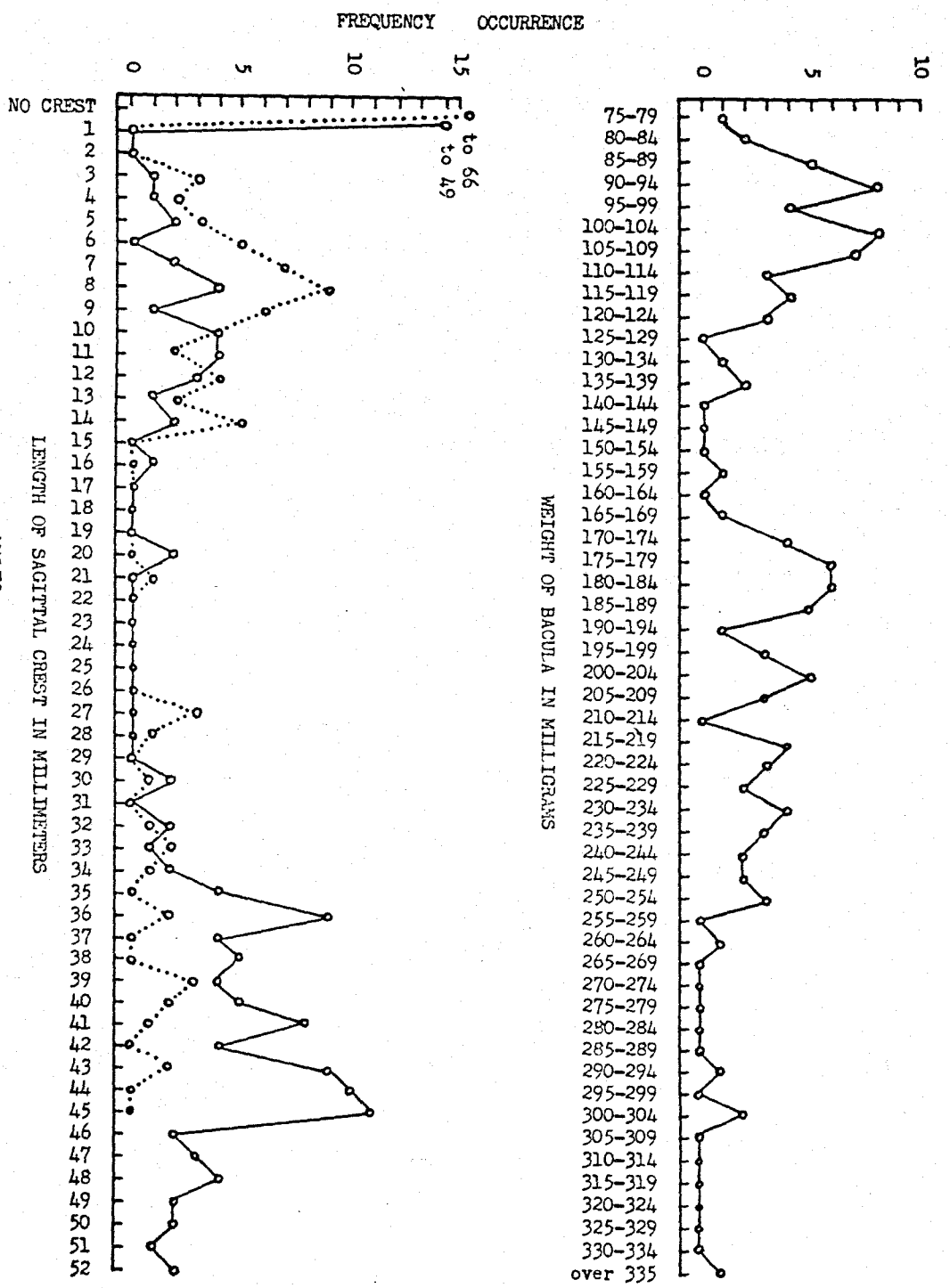

FREQUENCY OCCURRENCE
15
10
5
0
A
B
74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
SKULL LENGTH IN MILLIMETERS
40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
ZYGOMATIC BREADTH IN MILLIMETERS
MALES
FEMALES

Fig. 11. Frequency polygons of bacula weights and sagittal crest lengths to show their use as criteria of age.


FREQUENCY OCCURRENCE
0
5
10
15
NO CREST
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
to 66
to 19
LENGTH OF SAGITTAL CREST IN MILLIMETERS
MALES
FEMALES
0
5
10
75-79
80-84
85-89
90-94
95-99
100-104
105-109
110-114
115-119
120-124
125-129
130-134
135-139
140-144
145-149
150-154
155-159
160-164
165-169
170-174
175-179
180-184
185-189
190-194
195-199
200-204
205-209
210-214
215-219
220-224
225-229
230-234
235-239
240-244
245-249
250-254
255-259
260-264
265-269
270-274
275-279
280-284
285-289
290-294
295-299
300-304
305-309
310-314
315-319
320-324
325-329
330-334
over 335
WEIGHT OF BACULA IN MILLIGRAMS

additional material, especially from animals of known age, will increase the reliability of the age criteria, the considerable overlap of measurements indicates that absolute accuracy will never be attained.

Biology of Reproduction

Sex Habits.--Most investigators (Leekley, 1941; Marshall, 1951; Schmidt, 1934, 1942; Seton, 1929; and others) agree that marten are polygamous. Certainly polygamy is true of ranch-raised marten, and, although observations are lacking, it is probably also true of wild marten. Some animals, however, may show preference for a particular mate. J. W. Ritchie writes (in corr., 1952) of one instance in which a male marten refused to mate with more than one female, and of another instance in which a female produced 10 litters in 12 years, failing to produce only in those years when males were changed.

The Reproductive Cycle.--The evidence of a summer breeding season presented by Ashbrook (1927, 1930) provided the first description of any breeding season other than late winter for marten. Verification of Ashbrook's observations soon followed (Dulkiet, 1929; Murr, 1929; Prell, 1929; Schmidt, 1934; Walker, 1929; Wednagel, 1929). It is now established that both Eurasian and American marten breed during the summer, normally in July and August, and that there is no late winter breeding season.

Ashbrook (1930) indicates that many females have two or t

heat periods at intervals of one to two weeks, each lasting two or three days. In captive marten, matings may be repeated several times during a single heat period, or during subsequent periods, at intervals varying from a few hours to 39 days (Ashbrook, 1930; Brassard, 1939; Enders and Leekley, 1941).

Because mating occurs in July and August, and litters are normally born in April, the gestation period is about eight or nine months long. Ashbrook (1930) lists gestation periods which vary from 259 to 275 days, and Brassard (1939), from 220 to 230 days.

Although these breeding seasons and parturition periods are based on observation of captive animals, they probably do not differ appreciably from those of wild animals. Corroborating evidence is given by Walker (1929), who cites litter dates for wild Alaskan marten of the last week in March, April 4, April 14, and April 28. He also cites a mating date of July 4. During the present study, a female trapped on May 15 was still lactating, an indication of a recent litter because lactation lasts about six weeks. A female live-trapped on June 28 and again on July 2 was in breeding condition, as indicated by the swollen condition of her vulva. Males with descended and enlarged testes were caught on June 29, June 30, July 4, July 12 and July 15. An adult male with small testes was caught on August 24. It can thus be assumed that wild marten in Alaska normally mate in late June and July, and have their litters in April.

Reproductive Potential and Ecological Potential

If it is assumed that the population in question is properly balanced as to sex and age classes, four fundamental properties determine the reproductive potential of a species: 1) the minimum breeding age, 2) the maximum breeding age, 3) the number of young per year, and 4) the longevity beyond the maximum breeding age (Leopold, 1933). These factors are equally valid in the determination of the ecological potential, except that the values of the factors have been modified to varying degrees by the environment. Because in determining the ecological potential of a species it can not be assumed that the population is properly balanced as to sex and age composition, the mating habits of the species, and the sex and age composition of the population must also be considered.

The minimum breeding age.--The minimum breeding age of marten is normally about 27 months, the first litter being born when the parents are three years old. Some evidence, however, suggests variation, especially in the females, which may occasionally breed when only 15 months old or which may not breed until they are 39 months old.

Most comments on the minimum breeding age of marten found in the literature are general and of limited value. Marshall (1951) says the "females do not breed until their second summer and hence do not bear young until their third year." Dulkiet (1929)

reports that young females have no intercourse with males. Schmidt (1934) reported that many marten at one and one-fourth years of age do not have the ability to propagate and that about 80 percent do not breed until they are 27 months old. Later, he revised this estimate upwards on the basis of observations of 281 matings of which 122, or 43 percent, mated at 27 months and the rest showed no inclinations to mate even at this age (Schmidt 1942).

J. W. Ritchie, of the Western Canada Fur Farm, Busby, Alberta (in corr., 1952), says that most of his ranch marten first breed when two years old, though rarely when only one year old and occasionally not until they are three years old. Marten from Ritchie's stock when transported to California, however, are said normally to breed when only one year old. Leekley (in corr., 1952) comments on marten kept at the U.S.D.A. Experimental Fur Station at Petersburg, Alaska, as follows:

> As a rule marten in captivity do not breed until they are two years old. We have had an occasional year old female breed but they have never produced. In fact, the minimum age we have had a female produce is three years, though I am quite sure this does not hold true for marten in the wild.

Observations of wild marten during the present investigation largely corroborate the above data. In the examination of the reproductive tracts of 76 females, none of the 41 females which was considered to be less than 27 months old showed signs of being sexually mature. Of the 26 females thought to be in their third year, 22, or 85 percent, were pregnant and the remaining four showed no sign

of maturity. All 10 females older than three years were pregnant. A much larger sample would be desirable in verifying the above results.

The minimum breeding age for males seems to be the same as that for females. Schmidt (1942) says, "young males do not become sexually mature and ready to mate until they are more than two years old." Characteristics of the bacula of 112 marten examined in the present investigation indicated that none of the 34 animals which were less than one year old was sexually mature. Of those in their second year, 2 of 13, or 15 percent, showed indications of being sexually mature at 15 months, though in both cases the bacula had not quite reached the size which is normal in sexually mature animals. All 65 marten considered to be 27 months old or older seemed sexually mature.

The maximum breeding age. --None of the marten examined during the present study is thought to have been unproductive as a result of old age, although Marshall (1950a) found 3 females which he placed in this category. Ritchie (1941) cites two instances of females producing litters when 14 years old, and in correspondence (1952) he cites an additional instance in which a female bred each year until she was at least 12 years old, but failed to produce in the two succeeding seasons. In view of the advanced age at which captive marten are able to breed successfully, it seems unlikely that

individuals in the wild, except on rare occasions, fail to produce young because of old age.

Number of Young.--The best available information which has been found relative to the number of young produced per litter is derived from the records kept of captive marten. Schmidt (1942) reported the birth of 324 young in 108 litters, or an average of 3.0 young per litter, of captive sable. Leekley (in corr., 1952) reported an average of 2.62 young in 21 litters of marten born at the U.S.D.A. Experimental Fur Station at Petersburg, Alaska. Ritchie (in corr., 1952) writes that the average production of the marten on his ranch is about 3 young per female, although in some seasons they may average as many as 3.5 young per female.

Marshall (1951b) reported that, on the basis of corpora lutea counts in 21 females, the modal number of young per litter was three. In the present study, ovaries of females were examined under a binocular microscope or under a strong light with a hand lens. Of the 13 pregnant females examined, five had three corpora lutea, four had four, one had two, and three had only one. The average number of corpora lutea per pregnant female was 2.8. Although it was not possible to compare the number of corpora lutea and the number of young born to individual females, a comparison of the average number of corpora lutea and the average litter size as given above indicates practically no difference between the two. It may be possible

therefore to indicate the success of a breeding season by counting the corpora lutea in carcasses obtained from trappers.

Composition of the Population

The sex and age composition of a population is of considerable interest, because changes in composition reflect changes in other properties of the population. Thus, varying sex ratios in the harvest may indicate differential mortality or differential movements of sexes in a given age class, and age ratios may reflect the growth rate of the population, the success of a particular breeding season, or the intensity or trapping pressure.

Sex Ratios.--Sex ratios of marten at birth are approximately 100 males:100 females. Yeager (1950) reported that 19 of 22 marten ranchers to which he sent questionnaires indicated a 100:100 ratio among the kits; two reported a 200:100 ratio, and only one a 50:100 ratio. Leekley (in corr., 1952) reported a total of 23 males and 32 females in 21 litters born at the U.S.D.A. Experimental Fur Station at Petersburg, Alaska, or a ratio of 72:100. Schmidt (1942), however has reported 71 males to 47 females among the European spruce marten and quotes other ranchers, who report a ratio of 35 males to 30 females.

Sex ratios of trapped marten, which were obtained in the present study and those which have been reported in the literature or in correspondence, are listed in Tables 5, 6, and 7. A

preponderance of males is evident in each of the harvest records, averaging 159 males:100 females in the total series of 4817 specimens. Yeager (1950) attributed the preponderance of males in the harvest to a greater range of movement of the males which results in greater chance for being trapped.

Other data corroborate Yeager's findings. In live trapping operations conducted during the present study females were caught as easily as males, and in fact, re-captures of females were more frequent than of males. Trappers confirm the observation that females are caught as easily as males. Therefore, sex ratios of trapped animals do not seem affected by selectivity in trapping other than by selectivity caused by differential movement of the sexes.

Lampio (1951) reported a sex ratio of 461 males to 446 females for marten, Martes martes L., in the seasons of 1949-1950 and 1950-1951 in Finland. Lampio's data seem of special significance in indicating an equal proportion of the sexes in the population because they apply to animals which were harvested by hunting methods which involve the tracking of each marten until it is captured. The method thus avoids variations caused by differential movement of the sexes as is inherent in the harvest by trapping.

On dividing the harvest into two periods, October to December and January to March as in Table 6, Yeager (1950) found a marked increase in the proportion of females during the second period. This increase in the proportion of females he attributed to a relative

decrease in the number of males, and to greater movement of the females in the second period, caused by scarcity of food at the time of increased food requirements of pregnant females. DeVos (1952), however, considers the latter possibility dubious. Fabian Carey, a trapper who operated his trapline in Alaska only in January during the 1946-1947 season, recorded a catch of 7 males and 1 female marten. Though Carey's data are limited, they tend to substantiate DeVos' findings, for they indicate a greater movement of the male than of the female, independent of the season.

DeVos (1950) used Yeager's (1950) and Marshall's (1942) data on sex ratios to suggest the possibility of a differential mortality in the sexes. These combined data indicated a sex ratio of 48 males to 34 females among immature animals, and 33 males to 6 females among those animals classified as "old", an indication of loss in females. Differential mortality of the sexes, however, does not seem probable for there is complete lack of substantiating evidence, and the differential sex ratios can be as easily explained on the basis of movements.

DeVos' use of Marshall's "overmature" category to the exclusion of his "mature" category may also invalidate the conclusions reached, for Marshall's (1951a) separation of mature from old or "overmature" animals does not seem valid. In his classification, males with a sagittal crest of more than 30.0 mm. and females with a sagittal crest of more than 20 mm. are considered "overmature

TABLE 5. SEX RATIOS OF TRAPPED MARTEN[a]

Authority	Males	Females	Males per 100 Females	Total
Yeager (1950)	729	454	160	1,183
DeVos (1952)	777	479	162	1,256
Hagmeier (in corr. 1953)				
M. a. americana	385	251	153	636
M. a. caurina	256	170	151	426
Sub-totals	2,147	1,354	158	3,501
Present study				
1951-1952 season	350	198	176	548
1952-1953 season	460	308	150	768
Sub-totals	810	506	160	1,316
Totals	2,957	1,860	159	4,817

a/ Sex ratios of litters and of live-trapped marten are not included.

TABLE 6. SEX RATIOS OF TRAPPED MARTEN ARRANGED BY SEASON

Authority and Locality	October to December			January to March		
	males	females	males per 100 females	males	females	males per 100 females
Yeager (1950						
Alaska	21	11	191	1	1	100
California	158	92	172	116	92	126
Idaho	20	17	118	29	29	100
Colorado	206	98	210			
DeVos (1952)						
Ontario	94	48	196	112	120	93
Washington	571	311	184			
Present study						
Alaska	184	157	117	64	66	97
Totals	1,256	734	171	322	307	106

or very old". Alaskan data, however, indicate that the bulk of the breeding population is included among those which would be classified as "overmature" by the use of Marshall's criteria. The question arises, then, whether or not the measurements of Martes americana caurina (Merriam), the subspecies with which Marshall worked, are comparable to those of Martes americana actuosa (Osgood). Although average measurements of the adult marten examined by Marshall are slightly less than those measured in the present study, the modal pattern in a frequency distribution is almost identical with Alaskan material and falls well within the limits of age group categories used in the present study. Comparisons thus seem justified. Further doubt is cast on the validity of the criteria used by Marshall when it is considered that only 6 of the 110 males on which they were based could be judged breeding animals. In view of the above, combining Yeager's (1950) and Marshall's (1942) classes of mature and overmature animals before comparing them with the immature animals seems necessary. When these classes are combined, no significant difference is shown in the sex ratio, though the trend toward a smaller proportion of adult female as compared to males is indicated (Table 7).

In a series of 636 skulls of M. a. americana and 426 skulls of Martes a. caurina examined by E. M. Hagmeier (Table 7), the M. a. americana showed only slight difference in sex ratio between immature and mature animals, but the M. a. caurina showed a very significant difference when tested with chi square. Because both series

are composed of specimens from several museums, there is no readily apparent explanation for the difference between the two subspecies.

Sex ratios for the seasons of 1951-1952 and 1952-1953 in Alaska also show a significantly small proportion of adult females in the harvest (Table 7). This small proportion, however, is thought to be caused by the differential movements of the sexes and by the smaller size and greater stability of the home range of females as compared with that of males.

Age Ratios. --In a series of 1,256 marten compiled from several sources other than Alaska (Table 7), immature animals average about 46 percent of the population. In Alaska, the proportion of immature animals in the harvest varied from 56 percent during the 1951-1952 season to only 36 percent during the 1952-1953 season. The proportion of immature animals harvested during the 1952-1953 season differed very significantly from the proportion of immature animals in the 1951-1952 season, although there was no significant difference between the proportion of immature animals in either of the Alaskan series and the proportion of immature animals in the entire series listed in Table 7 (Chi square value for the 1951-1952 season is 2.97 and for the 1952-1953 season is 3.18).

The decrease in the proportion of immature animals in the harvest in the 1952-1953 season was evident for all areas in the Interior from which carcasses were obtained, although it was not reflected on all traplines (Table 8).

TABLE 7. AGE RATIOS OF TRAPPED MARTEN ARRANGED IN SEXES

Authority	Immature			Mature				
	males	females	males per 100 females	males	females	males per 100 females	Total	Percent Immature
Marshall (1942)	26	24	108	32	24	133	106	47
Yeager (1950)	22	10	220	39	17	230	88	36
Hagmeier (in corr.1953)								
M. a. americana	168	110	152	217	141	154	636	44
M. a. caurina	118	93	137	138	77	179	426	50
Sub-totals	334	237	141	426	259	164	1,256	46
Present study								
1951-1952 season	44	36	122	42	21	200	143	56
1952-1953 season	25	31	81	52	47	110	155	36
Sub-totals	69	67	103	94	68	138	297	46
Totals	403	304	133	520	327	159	1,553	45

The apparent decrease in the proportion of immature animals in the season of 1952-1953 is indicative of an unsuccessful breeding season. The immediate prospect after an unsuccessful breeding season is a slight decrease in the following harvest. Although complete figures for 1952-1953 are not yet available, a decrease in the harvest was apparent on several traplines, although not on others (Table 8). The most notable case was on a trapline in the Minchumina area, operated by Antoon Malde, on which 123 marten were trapped in the 1951-1952 season, but only 44 in the 1952-1953 season. Twenty-nine marten from this trapline were examined and every one was an adult.

The third trapping season after the one in which an unsuccessful breeding season is detected may be affected by lack of normal recruitment to the breeding population. The degree to which the lack of recruitment will affect the total population depends on the proportion of the breeding population that is formed by animals in their first year of maturity.

Another effect of an unsuccessful breeding season, though indirect, is that normal trapping pressure may be excessive on the decreased population. If reduced numbers engender increased movement, and evidence that they do is still lacking, the total harvest of mature animals might be greater than it would be if the population density were increased by normal recruitment of young. Such a result would be produced if lessened population density causes an increase in the size of home ranges.

TABLE 8. AGE RATIOS OF MARTEN IN ALASKA: SEASONS OF 1951-1952 AND 1952-1953

Area / Trapper[a]	1951-1952 Immature	Adult	Total	Percent Immature	1952-1953 Immature	Adult	Total	Percent Immature
Steese-Livengood	29	22	48	60	8	24	32	25
Bucholtz	5	5	10	50				
Draper	6	4	10	60	1	3	4	25
Lycher	13	10	23	57	6	19	25	24
Minchumina	21	19	41	51	45	62	107	42
Blackburn					26	13	39	67
Carey					3	5	8	37
Granroth					16	15	31	52
Malde	16	19	35	46	0	29	29	0
Willis	5	0	5	100				
Chena River	14	12	26	54	2	14	16	12
Jacobson	9	10	19	47	2	14	16	12
Yukon-Porcupine	11	6	17	65				
Totals	80	63	143	56	56	99	155	36

a/ The number of animals listed for each area does not necessarily equal the sum of the animals listed for the trappers in the area.

Changes in age ratios of animals taken from a single trapline or from relatively small areas may not always indicate changes in productivity. Areas which have not previously been trapped, or those that are lightly trapped, show a larger proportion of adult animals than is normal on heavily trapped lines. Several trappers have furnished supporting evidence for this fact by reporting a high proportion of "apple-headed" marten (marten with great zygomatic breadth) when they open new traplines. Conversely, overtrapping may be reflected in an abnormally high proportion of immature animals in the following harvest because of the influx of young, unsettled animals from neighboring areas.

Population Fluctuations

Cyclic fluctuations of marten populations have been described by several authors, including Seton (1911 and 1929), who, on the basis of Hudson's Bay Company records, suggested an eight to ten-year cycle; and by Elton (1942), who, from examination of the records of Moravian Missions in Labrador, suggested a three to five-year cycle. Though the fluctuations are not so periodic or predictable as is often indicated, they are a factor which must be considered.

As yet, neither the characteristics nor the causes of the fluctuations in marten have been adequately demonstrated. Seton (1929) pointed out the relationship of the marten cycle to the rabbit cycle, the marten population reaching its maximum about midway on the up-

swing of the rabbit cycle. On the basis of the relationship between the rabbit and marten cycles he suggests that fluctuation of the population is due to "greater or lesser fertility of the female", which may be caused by "starvation or overfeeding" at the low or the high point in the rabbit cycle, the fertility being decreased in either case. Although studies of the food habits of the marten by Cowan and Mackay (1950) indicate that the rabbit is not a sufficiently important food of the marten to be influential in its cyclic behavior, the food supply may still be a factor. Lack of food has frequently been shown to result in lowered productivity of animal populations, and excessive feeding of captive animals produces similar results. Whatever the cause, unsuccessful breeding seasons is probably the chief factor involved in the fluctuations of the population. There is no indication that disease may be a factor.

Records of the Hudson's Bay Company, discussed by Seton (1929), show that population fluctuations are widespread and are not influenced by trapping. Records of harvests in British Columbia since 1922 (Cowan and Mackay, 1950; and Eklund, 1946), however, show that under the registered trapline system fluctuations such as those noted by Seton (1911 and 1929) are much less marked. Fluctuations of marten populations, however, whether they are a predictable cyclic behavior or a random fluctuation as suggested by Cole (1951), may be expected.

The natural fluctuations of the marten population in Alaska

have been so masked by fluctuations caused by harvest regulations that harvest records offer no clue as to the actual causes of the fluctuations (Table 1).

MOVEMENTS

Information relative to the movements of any animal is desirable, often essential to its proper management. Important aspects of the movements of an animal include the daily activity pattern and factors which influence it, variation in activity by season, the extent and stability of the home range, territorialism, migratory habits, and rate of dispersal.

The activity pattern of the marten can be determined only by extensive field observation and by tracking many individual animals, preferably in conjunction with live trapping operations so that the sex and age of the individual being followed may be known. A limited amount of information on the home range can be obtained in the same manner, but for accurate knowledge of home range, total lifetime range and the dispersal rate, live trapping, tagging and subsequent recapturing of individual animals is necessary. Although live-trapping operations are time consuming and the follow up which is necessary requires a project of several years duration, the value of information which can be obtained seems to justify the effort.

Live-Trapping Operations

Successful attempts to live-trap marten have been reported by Newby (1951), who worked in the Cascade Mountains in Washington, Rost (1951) in the Uinta Mountains of Utah, and DeVos and Guenther (1952) in the Cascades and in Ontario. The techniques used by each

of these investigators were essentially similar. All investigators used a welded-wire, collapsible live-trap made by the National Live Trap Company, Tomahawk, Wisconsin. DeVos and Guenther (1952) also used Havahart and steel traps with padded jaws, but they found the former too bulky and inefficient and the latter often injurious to the marten. Very little mortality in the live trapping operations was experienced except by Rost (1951), who attributed his losses to his inability to check his traps daily. DeVos and Guenther (1952) reported that losses were slight, and Newby (1951) apparently lost no marten during his operations.

A variety of baits may be used to attract marten. Many trappers use only a bright tin can, a piece of hide or red flannel, or a piece of cardboard--with or without the aid of a scent. In live-trapping it was found that the easiest bait to use was a sheet of aluminum foil in combination with a scent which was made from beaver castors, marten scent glands, or from rotted meat. Squirrels, parts of grouse, birds, mice or other meat were also used with success. In winter operations, food was placed in the trap in the hope that this would compensate somewhat for the enforced inactivity and abnormal exposure of the marten while in confinement.

At first trapped marten were handled with the aid of a cone made of wire mesh. Later it proved easier and more efficient to merely grasp the marten by the neck with a mittened hand. Tags can be inserted and most measurements taken with the free,

ungloved hand. The marten struggle less and become much less excited by this seemingly rough method of handling than they do when the cone is used. A real boon in the handling of marten is its voracious appetite and its fondness for jam or candy bars (see Food Habits). In nearly every instance marten cease struggling and ignore the pressure of the hand around their neck while they lick jam from a spoon.

Marten were normally released at the point of capture immediately after they were tagged. The most characteristic reaction on finding themselves at liberty was to bound swiftly for a distance of 10 to 20 yards and then stop to look back, often sitting up to get a better view. Apparently normal hunting activities began immediately after release.

Live-trapping during the present study was conducted at Castle Rocks, near the northwest corner of McKinley Park (Fig. 13), at Murphy Dome (Fig. 14), about 20 miles west of Fairbanks, and at Cassiar Creek opposite mile 55 on the Steese Highway. Castle Rocks was chosen as a trapping area because harvests in the surrounding region have been consistently excellent for several years and because trappers in that vicinity indicated their willingness to cooperate with the project. The Cassiar Creek and Murphy Dome areas were chosen primarily for their relative accessibility.

Trapping operations were first conducted at Cassiar Creek from May 10 to 16, 1952 and were designed to check equipment and

procedures prior to the initiation of summer field work. To that extent they were quite successful. Eighty-eight trap units (one trap unit is equal to one trap set for a period of twenty-four hours) resulted in the capture of a single female marten which died in the trap. She had apparently become wet and had thus suffered undue exposure. This fatality, which occurred at a temperature of about 32° F., was the only one during the study, although later trapping operations were carried on in temperatures of less than 0° F.

Summer trapping operations at Castle Rocks were conducted from June 26 to July 24, and from August 13 to August 30, 1952. Trapping was greatly facilitated by the use of a section of a trapline owned by Ray Tremblay (indicated by red line in Fig. 13). Thirty-six traps were distributed along this line at intervals of 400 to 600 yards, depending on the presence of "cubbies" used by Tremblay in normal trapping operations (Fig. 15), and on physiographic features along the trapline. Wherever possible, traps were placed in cubbies, but in some instances they were set along the trail and covered with moss or spruce branches. This covering was not intended as camouflage, for none is necessary, but was used to allow marten to approach the bait only from the front of the trap.

After the line had been traveled a few times, it proved advisable to move some traps to more suitable locations as indicated by the relative abundance of scats found on different sections of the trail. A total of 50 trap sites were used in the course of the

operation, although the 16 captures of marten were made in only nine of the locations.

Winter operations were conducted on Murphy Dome from November 13 to November 28, 1952. Nineteen traps were located on three short lines at the head of ravines which were used by marten as foraging areas. Traps on the middle line were set in cubbies as in previous operations, but in view of the lack of fear and suspicion displayed by marten, small kennels made from cardboard boxes were used instead of the cubbies on the other two lines (Fig. 16). These proved very satisfactory. Marten entered the boxes without hesitation, traps could be placed or relocated with a minimum of effort, and the boxes provided much better protection from cold and snow than did the cubbies.

Trapping success varied considerably between areas, but differences apparently are due to the season of the year and to corresponding changes in availability of food. Best results were obtained at Murphy Dome where 11 captures of four marten were made with an effort of 279 trap units, or an average of one capture for every 25.4 trap units. Summer operations at Castle Rocks, in the period from June 26 to July 24, resulted in 14 captures of nine marten in 992 trap units or an average of one marten for 71 trap units. At the same location for the period from August 13 to August 30, 562 trap units produced only two marten or an average of only one capture per 281 trap units.

Fig. 13. Map of Castle Rock Area. The lines of four trappers are indicated in black; the small segment of line 4 used in live trapping operations is indicated in red.

Map from U. S. Geological Survey, McKinley Quadrangle, Edition of 1952. Scale 1:250,000.


Cabin
Mountains
ROAD
Lake Tukomina
Lake Telida
Landing Area
Telida
SLED
FORAKER
BIRCH
Fork
Skwentna River
HERRON
BIRCH RIVER

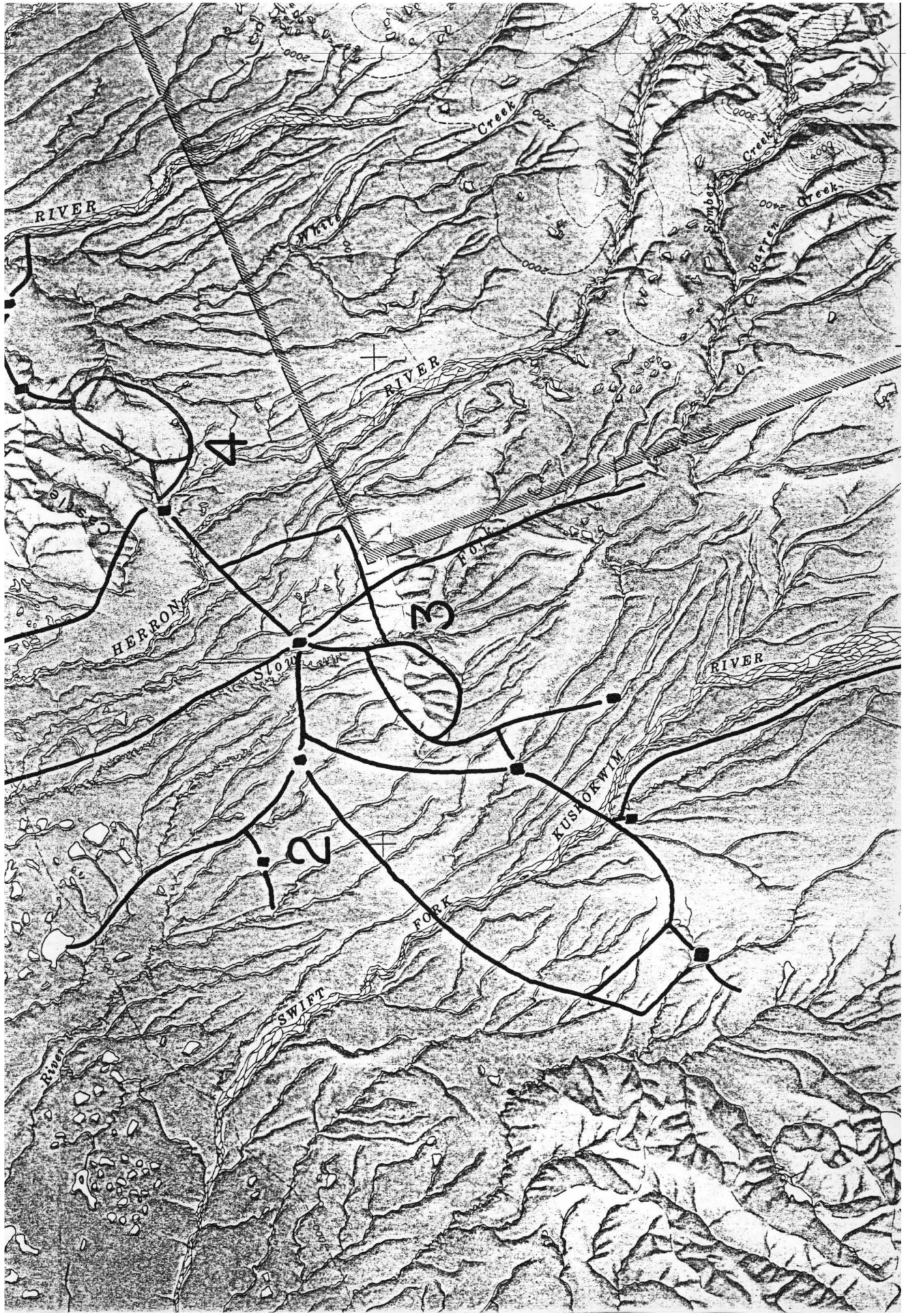
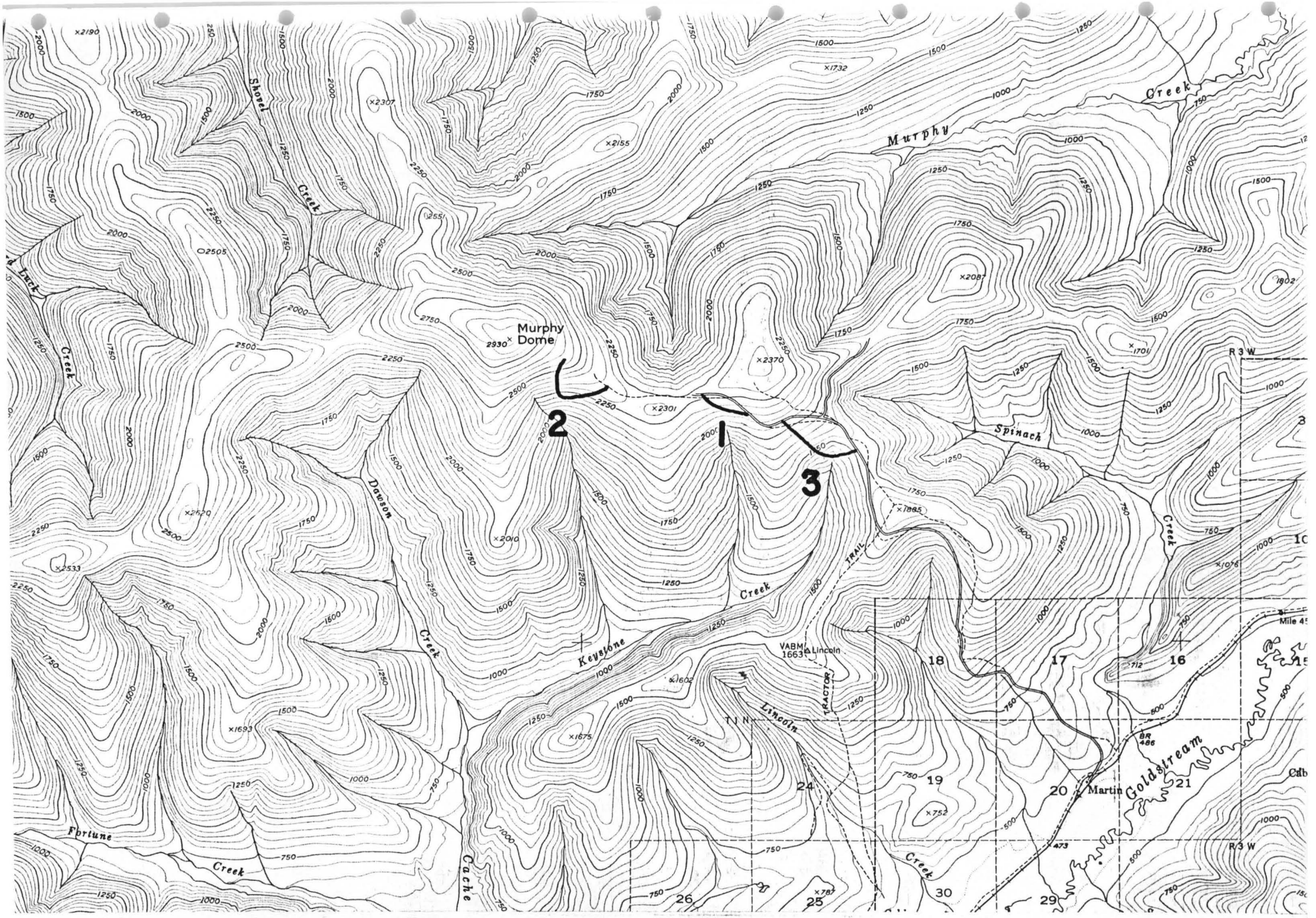

RIVER
White
Creek
Somber
Creek
Barren
Creek
RIVER
HERRON
RIVER
KUSKOKWIM
FORK
SWIFT
River
4
3
2

Fig. 14. Map of Murphy Dome Area. Traplines are indicated by heavy lines. Green shading roughly delineates areas in which spruce predominates.

Map from U. S. Geological Survey, Fairbanks (D-3) Quadrangle, Edition of 1952. Scale 1:63, 360.


Murphy Dome
2930
Murphy
Creek
Short
Creek
Dawson
Creek
Keystone
Creek
Cache
Creek
Fortune
Creek
Spinach
Creek
Goldstream
Creek
Lincoln
TRACTOR
TRAIL
VABM
1663
Lincoln
Martin
T 1 N
R 3 W
R 3 W
2
1
3
18
17
16
19
20
21
24
25
26
29
30

The best trapping results are obtained in the winter period when rodents and berries are covered by snow and are less readily available to marten. The difference in the success of the two summer operations at Castle Rocks seemed to be due almost entirely to the abundance of berries which had become available by the second period. During the time when berries were available, scats were frequently found near traps, and on one occasion even on a trap, without the marten having entered. In contrast to this, marten entered every trap which they encountered during winter operations and seemed to be definitely attracted by the bait and scent.

The success of operations in Alaska is comparable to that elsewhere. Summer operations were reported to be less successful than winter ones by both Newby (1951) and DeVos and Guenther (1952).

The Activity Pattern and Characteristics of Movement

Marten appear to be primarily crepuscular or possibly to some extent nocturnal in habit, though they may at times be abroad during daylight hours. Trappers seldom report seeing marten during the day, nor has one been seen during the day in the course of the present investigation. Schmidt (1934, 1942) reports crepuscular habits for Siberian sable and European marten, but Brehm (1914) classifies European marten as "night" animals, and Koshantschikov (1930) says that individual sable may vary in habit and that there are "day" and "night" resting animals.

Marten when hunting, often seem to travel in an aimless, erratic fashion, detouring with no apparent reason, circling across or even following their own tracks, investigating the base of one spruce with a great deal of care only to ignore the next. If the tracks are followed for a sufficient distance, however, it becomes apparent that there is an objective in the manner of hunting and that a predetermined though pliable route is followed. The erratic manner of hunting provides for a thorough coverage of the hunting area. Detours often lead to particular windfalls or rock piles, showing the marten's intimate knowledge of the area.

Marten normally travel in a rather leisurely, bounding gait, but may frequently slow to a walk for a few paces, especially in dense cover or when investigating some particular place of interest. Stops may be made at intervals, commonly at points where the surrounding terrain can be viewed. It is frequently impossible to tell by tracks where marten make their kills. Open areas are usually avoided and when they are crossed, the marten usually travels in a more direct route than at other times. Much of the literature reports arboreal habits of marten, but in the present investigation there has been no instance where one was known to have climbed a tree. Leaning or nearly prostrate deadfalls, however, are frequently climbed and on one occasion marten tracks were found on the roof of an abandoned cabin--a not unusual occurrence where marten are common. Progress over the hunting route apparently

varies with many factors, among which climatic conditions, physiography, the stage of the sexual cycle and the abundance of food seem most important.

Observations are still too limited to permit a full evaluation of the effect of weather on movement or activity. Trappers report that marten are most active in the fall and early winter but that activity declines to a marked degree during the extremely cold weather of December and January. Considerable activity, however, is reported for late February and March when temperatures are milder. Similar increased activity in the spring has been reported for the sable and marten in Europe and Siberia and for the marten in other regions of North America. Misinterpretation of this increased activity in the spring undoubtedly has contributed to the erroneous reports of a spring rut described by Brehm (1914), Malaise (1929), Mallner (1931), Seton (1929) and others. Schmidt (1934) attributed the increase of activity in the spring to playfulness of immature animals brought about by the milder weather. Dulkiet (1929) noted considerable activity of sable on the Shantar Island during this period, which he called "false heat", but he found no evidence of rut.

Wet, rainy weather (possibly even heavy dew) may limit activity. Live-trapping operations conducted by the author seemed less successful when the ground or vegetation was wet, though no correlation was found between catch records and precipitation records of the Minchumina Station. Val Blackburn, a trapper, also noted a

similar lack of success when trapping under wet conditions and did not even feel it necessary to tend his traps after a rainy night. Seton (1927) quotes Aumock, who says that captive marten on his Colorado ranch remained in their dens during rainy weather, except for very brief excursions for food. Schmidt (1942) comments on the relationship of weather and activity of ranch marten as follows:

> Pronounced bad weather, such as periods of rain, delay and are not favorable to the rut. The martens do not seem to mind humidity, and they seem to enjoy warm rain but continuous downpours, usually followed by cooling off, have an unfavorable influence on their activities.

Deep snow may tend to increase activity during the winter. The relatively large feet of marten permit them to travel with comparative ease even in soft snow. At the same time, their prey is protected to a measure by the snow, and greater effort and travel are required to obtain food. In the winter of 1952-1953 a limited snowfall in the interior of Alaska made food more accessible than normal and many trappers reported that, although the marten population seemed normal, there was less activity than usual. The lack of activity may have been reflected in the low harvest, though other factors may also have been operative.

When a favored food is abundant, movement may at times be restricted to a very small area. In November, 1951 Viereck and Lachelt (1951) found eight sets of tracks of varying freshness leading into a blueberry patch of about fifty feet in diameter. A marten had apparently stayed in the area to forage on the berries for a period of

several days. Al Lycher, a trapper, told of several similar instances which he had observed in the White Mountains. On Cassiar Creek several scats were collected in the vicinity of a caribou carcass on which the marten had fed for several days.

No discernible variation in daily activity has been observed between sex or age groups. It seems possible, however, that the polygamous males are more active and may range more widely during the breeding season than at other times.

Territory and Home Range

The concepts of territorialism and home range of animals have been described for many species of birds and mammals and may in fact be one of the fundamental properties of an animal population. In each species territorialism is distinctive and possesses many characteristics which, when understood, have wide application in game management. An excellent discussion of territoriality and home range concepts as applied to mammals is given by Burt (1943, 1948). Territory, which he defines as "any defended area", should not be confused with the home range which he defines as "the area around the home region that the animal traverses in its normal activities of food gathering, mating and caring for its young." Both the territory and the home range may be permanent, semipermanent, or seasonal. In the following discussion Burt's concepts of home range and territory will be followed.

Territory.--No report of territorialism as such has been found in the literature on the marten, nor has conclusive evidence been found in the present study to suggest that it exists to any marked degree. It seems probable, however, that a sort of territorialism may exist during the rut on the part of the males and during late pregnancy and for a period after parturition on the part of the females. The pugnacity of the male marten has been remarked on by several authors and scars on the skulls of several animals examined during the present investigation bear testimony of previous conflict. Increased activity in the spring, which at times includes fighting, has been described previously in this paper. It is suggested, admittedly on dubious grounds, that this may be evidence of territorialism on the part of the female.

Territorialism in the marten, so far as it is understood at the present time, does not appear to have important management significance. It is possible, however, that territories exist and if so, they may be one of the controlling factors on the upper population limits of the marten.

Home Range.--Several papers concerning the ecology of the marten have commented on the extent and characteristics of its home range. These data are not, perhaps, strictly comparable with those of marten in interior Alaska for they are concerned with several races and species under a varied set of climatic and physiographic

factors. They do, however, emphasize the relationship of the animal to changes or differences in its environment and the control which the environment may have on the fundamental properties of the species.

Brehm (1914) says that most spruce marten have a "fixed home" though many "wander". Other authors, working primarily in Siberia, have given a much more detailed account of the home range. Koshantschikov (1930) commenting on the sable, Martes zibellina L., in the Sajan Mountains of south central Siberia to the west of Lake Baikal says:

> Each sable has in the forest a fixed living range. The individual ranges vary their sizes and fluctuate between 2 to 10 square kilometers. The size depends on the forest (the forest type) and on the topography. The number of species and individuals of birds and mammals are directly proportional to these factors, and hence the quantity of food.

In discussing the "living range" (home range) of the sable, Koshantschikov divides the area into three zones on the basis of habitat. The first zone includes the foothills and slopes of the Sajan Mountains from elevations of 400 to 600 or 800 meters. The climate is moderate and snowfall varies from .75 to 1.5 meters. The vegetation of most of the zone consists of a mixture of Pinus sylvestris and Larix sp. with many openings. Deep cool valleys and north slopes of mountains may have coniferous stands. It is only in the coniferous area that marten are found. The home range of the sable in this zone varies about 2.5 to 4 square miles.

The second zone consists of a dense, uniform coniferous forest at elevations from 700 or 800 meters to 1,400 or 1,500 meters. The climate is quite cold and snowfall is from 1 to 1.5 meters. Clearings are scarce and the entire area is densely populated with sable; the average home range is about 1 to 2.5 square miles.

The last zone is a sparse subalpine forest at an elevation of 1,400 to 1,700 meters, although locally it may reach elevations of 2,000 meters. The climate is severe and there is seldom less than 2 meters of snow. Marten are found only in the forested river valleys; here the home ranges average about 2.5 square miles.

Where there is diversity in the habitat the section of the home range used by the sable varies seasonally with local changes in abundance and characteristics of preferred foods.

Mallner (1931), also working on sable in the Sajan Mountains, says that the individual lifetime range is about 20 to 25 quadratverst (about 9 to 11 square miles). This might include the headwaters of two or three adjacent mountain streams, two or three neighboring ridges or a section of stream-bottom forest.

Malaise (1929) found that the hunting area of the sable on the Kamchatka Peninsula was about 10 square kilometers or 4 square miles.

Perhaps the most interesting investigation of the home range of the sable is provided by Dulkiet (1929) on the basis of a four year

agree, however, that the range of the female is smaller than that of the male. The accuracy of trappers' reports undoubtedly varies, but most error has probably been in the interpretation of observations which in themselves are usually reliable.

Gene Morris, a long-time trapper and resident of Alaska, told of tracking a male marten for a distance of 25 miles and he did not consider that distance greater than the marten's normal range. Al Lycher, a trapper at the southern edge of the White Mountains, believes that males and possibly young females may move as a loosely organized group over a range exceeding 50 miles in length. However, he considers adult females quite sedentary. Blackburn, Malde and Tremblay, trapping in the Minchumina and Kantishna area, believe that most marten are quite sedentary, but that the males may have a greater range than the females.

Trapping operations have furnished some concrete evidence of movement. Malde lost 12 marten by "ring-offs" the first year of trapping a newly opened line. In the second year of trapping the line he caught 5 marten with missing feet, apparently those lost from the same line the preceding year. In a similar situation, Tremblay lost 5 marten by ring-offs. Two of these were thought to have been caught by Blackburn on an adjacent trapline in the following season at a distance of 8 to 15 miles.

In no instance has the author tracked a marten for the full limit of even a day's travel, although several have been trailed

distance of two to three miles. Viereck and Lachelt (1951) reported trailing marten for about the same distance. They also found tracks of a marten crossing three-fourths of a mile of open tundra and others crossing Wonder Lake which is about one-half mile wide, indicating that the marten was familiar with the area on the far side.

Sex and age ratios offer interesting evidence on the variability of movement between sex and age groups and on the stability of the home range. It has been noted (see Composition of the Population) that on newly opened traplines or possibly even on lightly trapped lines, the proportion of adult to young animals is higher than on a heavily trapped line. In addition, on a regularly trapped line, the ratio of young to old females is greater than the ratio of young to adult males (Table 7). A preponderance of males in the harvest has also been noted.

Each of the above variations from the expected sex or age ratio can be most easily explained on the basis of differential movements and size of the home range in sex and age groups. The higher proportion of adult to immature animals taken on the opening of a new line indicates the stability of the home range, and that home ranges (possibly territorial behavior within the home range), though they overlap, may have some control of the maximum number of individuals in the population. The immature animals are thus forced to move from areas already occupied by adults, to less favorable, or unoccupied areas. If the assumption that the home range of the

female is smaller and more stable than that of the male is valid, it would follow that the system of trapping employed in Alaska would tend to harvest a high percentage of the total number of females along the trapline each year; at the same time, however, females a relatively short distance from the line would not be harvested. Males, on the other hand, would be taken from a considerably larger area. The "vacancies" left by the trapping would tend to be filled by the younger females which had not previously established a home range. Briefly, a cross section of the entire population probably is taken in the harvest of males, but in the harvest of females the population is selectively sampled for the elements (mostly immature females) which have moved into the home ranges made vacant by the previous harvest.

The preponderance of males in the harvest and its possible relationship to differential movement is excellently treated by Yeager (1950). Males, because they hunt a greater territory than the females, are more likely to be caught. The apparent increase of the proportion of females caught late in the season is considered by Yeager to be due primarily to the comparative decrease in the total male population as compared to the decrease in the female population, rather than to a change in habits of the female.

Live-trapping operations have as yet provided only a limited amount of information on the extent of the home range. In the operations at Castle Rock during the summer of 1952, 11 marten were

captured, three of which were re-captured one or more times. Two males were re-captured at intervals of 5 and 15 days respectively, each in the same trap in which it had first been caught. An adult female was caught four times at intervals of 1, 3, and 18 days in three traps which were separated by a linear distance of about 925 yards. Four adult males, three juvenile females and one juvenile male were caught only once.

Four marten were caught near Murphy Dome. An adult female was captured a total of five times in 15 days at traps separated by a distance of about two miles. This animal was back-tracked two additional miles, making the total linear distance known to have been traveled by the marten at least four miles. Another adult female was re-captured twice at intervals of two and four days at traps separated by about 600 yards. A juvenile male was re-captured after seven days in a trap about 1,400 yards from the point of its original capture. Another juvenile male was caught only once during the trapping period of 15 days.

It seems significant that the three adult females captured were re-captured on several occasions, whereas only two of the six adult males caught were re-captured, and then only once. Three juvenile females and two juvenile males were also caught only once. The distribution of captures among sex and age groups would seem to indicate clearly that the home range of the adult female is smaller

and perhaps more stable than that of adult males and immature animals.

Migration

Except for the seasonal, vertical movements attributed to marten in certain localities and the normal radiation or dispersal of animals from foci of the population, the marten can not be considered a migratory species. Only a single reference to a definite movement of numbers of marten involving permanent migration to a new area has been found in the literature. Mallner (1931) says:

> Migrations, as we have observed with other animals, are seldom found in the sable. One took place in the Sajan Mountains about the year 1875; the second and last in 1900. At that time when the great movement from European to Siberian Russia began--accompanied by terrific forest fires--the little predator traveled across wide stretches and criss-crossed the largest Siberian rivers. It was not entirely lack of food that occasioned the migration.

Seton (1929) reported many conflicting opinions regarding the migration of marten, but his evidence indicates that although there may be some local movements, marten are not generally migratory. Hudson's Bay Company reports show that declines in the population are so widespread that the possibility of migration is refuted, for if such were the case, population declines in one area would be matched by corresponding increases of population in another.

Migratory movements of sable across the Finnish frontier from the western part of Siberia as described by Lampio (1951) seem

to be the result of a normal dispersal pattern. Lampio (in corr. 1952) says that "movements take place mostly from east to the west and sometimes trips up to 200 miles are known." Because there is apparently some movement in both directions it seems probable that the movements are due to normal dispersal tendencies; that the high proportion of movement is in one direction, however, is probably caused by factors such as a difference in population level between the areas or to unequal quality of the habitat.

Newby (1951) describes seasonal, vertical migration of marten in the Cascade Mountains from summer ranges at elevations between 4,000 and 5,500 feet to winter ranges below 3,400 feet. Rost (1951) also describes seasonal vertical movements of marten in the Uinta Mountains, but believes that movement is upward in winter. Rost's information, however, is so limited that his observations are inconclusive. Migration of marten in winter from the mountains to the beaches along the coast of southeastern Alaska is reported by local trappers and Fish and Wildlife Service agents. Although these movements have not been confirmed by observation of marked animals, they seem valid.

The cause of the seasonal movement is probably due to seasonal variation in availability of food at different elevations. In southeastern Alaska where excessive snowfall in the mountains makes food much less available than on the beaches where high tides not only

wash the snow away, but constantly replenish the supply of marine food, variation in abundance of food is certainly a factor.

Dispersal

In considering the dispersal of the marten we are primarily interested in the rate at which an unpopulated or understocked area may be repopulated through dispersal movements, and the effect that dispersal from refuge or protected areas may have in maintaining the population in surrounding areas which are harvested. Provided the habitat in which movement is to take place is suitable, the factors which must be evaluated in determining the rate of dispersal include the mobility of the animals involved, the reproductive capacity of the species, and the population pressure at the focus of radiation.

The increase in a population due to dispersal into an understocked area is difficult to separate clearly from the increase in population due to the normal gain of the residual population. DeVos (1951), however, was able to indicate the effect of dispersal by showing that the increase in the population of fisher and marten in the area surrounding the Chapleau Game Preserve in Ontario could not be entirely accounted for on the basis of the productivity of the residual population. Although the population was greatest in and near the preserve and gradually decreased to a distance of 35 to 45 miles, the proportion of gain was less in the more highly populated areas and indicated that the dispersal trend was directed from areas of high population to

those of low population. This may not indicate, however, that population pressure forces the dispersal at an increased rate in one direction, for a sort of di fusion relationship, or equal rates of movement in both directions, is equally plausible. In the latter case, the large increase in the area of low population is merely a result of the greater number of chances for dispersal from the high population. The importance of sociability and intraspecific tolerance, the rigidity of territory and home range, and other problems must be more fully explained before the effect of population pressure can be understood.

In the discussion of the range of marten it was indicated that the adult females were relatively sedentary as compared to the males and immature animals. The effect of actual movement of adult females into a new area, therefore, is probably of minor importance, and the repopulation must depend on the movement of immature females which had not previously established home ranges.

The extent and characteristics of movement of young animals is as yet unknown, but may involve movements for considerable distances. Because the available information on the sable indicates that adults are sedentary (Brehm, 1914; Dulkiet, 1929; Koshantschikov, 1930; Mallner, 1931; and others), it seems likely that the movement of sable across the Finnish frontier from western Siberia as described by Lampio (1951) may largely be attributed to movement of young animals.

The relatively low reproductive capacity of the marten, coupled with the dispersal of only immature animals into a new range, would permit only a relatively slow establishment of a population over any considerable area. Dispersal movements, however, may contribute significantly to stabilization of populations adjacent to refuge areas or to the restocking of localized areas such as an overtrapped line.

FOOD HABITS

Information on food habits was obtained in conjunction with other phases of the study. Scats were collected during live-trapping operations and during general field work. Digestive tracts were saved from most carcasses obtained from trappers. The contents of the scats and digestive tracts were analysed by Ronald O. Skoog, a graduate student at the University of Alaska. His findings are used in this discussion. Because few skeletal remains occurred in either the scats or digestive tracts, most mammalian identifications were made by examination of hairs. In most instances the use of material from digestive tracts of trapped animals, which had fed on bait or debris while in the trap, caused no error in the sample because debris and bait which had been ingested could be separated from normal food items with slight difficulty. Summer and winter foods of the marten are itemized in Table 9.

Mice were found to be the most important food item by Cowan and Mackay (1950) in British Columbia, Dulkiet (1929) on the Greater Shantar Island, Koshantschikov (1930) in the Sajan Mountains of Siberia, Malaise (1929) on Kamchatka, and Raevsky (1938) in the Ural Mountains. Squirrels, birds and berries were listed as common food items in all these studies, but were much less important than mice. Squirrels were found to be the most important food of marten in Montana by Marshall (1946), and in Washington by Newby (1951),

TABLE 9. SUMMER AND WINTER FOODS OF MARTEN EXPRESSED AS PERCENT OF FREQUENCY OCCURRENCE

	ALASKA[a]		BRIT. COL.[b]		GR. SHANTAR IS.[c]	MONTANA[d]	WASHINGTON[e]	
	Summer	Winter	Summer	Winter	Summer Winter	Winter	Summer	Winter
Microtines	74	68	59.0	9.9	71.7	14	13.4	27.4
Squirrels		2	12.9	4.8	7.9	59	9.6	40.5
Shrews			2.0	0.9	2.0			
Lagomorphs		1	2.0	4.8		9	5.2	2.7
Birds	8	19	5.9	0.9	5.9	7	3.0	8.1
Insects			7.9			1	54.7	
Berries	18	9	5.9	3.8	0.7		8.2	2.7
Other		1			11.8	10		

a/ Summer foods based on 469 items in 374 scats; winter foods on 107 items in 28 scats and 64 digestive tracts (present study).

b/ Summer foods based on 202 items in 112 scats and 3 stomachs; winter foods on 104 items in 85 scats (Cowan and Mackay, 1950).

c/ Winter foods based on 152 items (Dulkeit, 1929).

d/ Winter foods only, based on 77 items in 64 scats (Marshall, 1946).

e/ Summer foods based on 78 scats and one stomach; winter foods on 17 scats and 16 stomachs (Newby, 1951).

f/ Items which are not listed include caribou (obtained as carrion) and marten hair. Debris from digestive tracts of trapped animals is not included in calculations.

although Newby found that insects formed the most important food in summer. Lagomorphs (mostly Lepus sp.) were relatively unimportant, except in Montana where Marshall (1946) found that they represented 9 percent of the winter food.

Food habits of marten in interior Alaska are similar to those reported for Asiatic species. This similarity is not surprising for both faunal and floral elements of the marten's environment in Asia are similar to those in Alaska.

In Alaska, during the present study, microtines, mostly Clethrionomys rutilus dawsoni (Merriam), Microtus xanthognathus (Leach), and Microtus spp., were the most important food of marten. They comprised 74 percent of the summer food and 68 percent of the winter food. Berries (chiefly blueberries, but some crowberries and bearberries) were second in importance, comprising 18 percent of the food in summer and 9 percent in winter. Berries were most used in late summer and fall, when at times they equaled or exceeded microtines in importance. Avian foods formed about 8 percent of the summer food and 19 percent of the winter food. In summer, avian food seemed to consist mostly of young birds, probably passerines, but in winter consisted mostly of grouse or occasionally ptarmigan. The proportion of avian foods found in winter may be somewhat exaggerated, for parts of grouse are used by some trappers for bait and would be reflected in the analysis of digestive tract contents.

The varying hare, Lepus americanus dalli (Merriam), and the red squirrel, Tamiasciurus hudsonicus petulens (Osgood), appeared in the marten's diet only in winter when they formed 1 and 2 percent, respectively, of the total food. These proportions may be low, however, for field observations indicate that in some areas they may have greater importance than is indicated by the above figures. Red squirrels and varying hares are both relatively uncommon in the Minchumina area from which a large proportion of the scats and carcasses was gathered.

A few items which might be expected in the diet were conspicuous by their absence. Among these were shrews, Sorex spp., and low-bush cranberries, both of which are common in interior Alaska. Cowan and Mackay (1951) and Newby (1951) also noted the rarity of shrews in the food of marten, and attributed the lack to the strong smell emitted by the musk glands. Cranberries were found commonly in scats of marten collected in British Columbia by Cowan and Mackay.

Foods accepted by captive marten are of interest because they reflect the adaptability or flexibility of the marten's diet. Remington (1950) listed pancakes, gravy, shrews, raisins, ham, wheat cereal, trout, lettuce, spaghetti, bread and celery as foods which were eaten by captive animals. Raisins seemed a much preferred food item, and salamanders and live toads were avoided.

Food habits of marten trapped during the present study indicate the important role that food-getting has in the marten's activities. Edible baits were always utilized and food was readily accepted from the fingers of the author (sometimes the fingers as well) while the marten was still in the trap. On one occasion a female was given a candy bar and then released. She carried the candy to a distance of about ten yards where she stopped and ate it in full view of the author. Other marten, when released from the live-traps, usually began hunting in an apparently normal fashion when they were only a few rods away from the trap.

Wild marten which were held for a short time in cages were quarrelsome, and viciously attacked any object which was held near them. When a spoonful of jam was held to the cage they struck at it as before but on discovering the apparently pleasant taste of the jam, they released the spoon to lick it. Later it was found that even when they were held by the neck, sometimes almost being strangled, they would cease struggling to lick jam from a spoon. This behavior emphasized the incidents described in the above paragraph on the importance of food-getting. The entire psychology of the marten seems to center on food; fear, anger and discomfort are dominated by this single urge.

The results of the present study and those of other investigators, indicate that marten are adaptable in their food habits. The

governing factor in the selection of food is availability. What is eaten depends on what food is most easily obtained, and almost no preference is shown for particular food items.

MANAGEMENT

Four approaches to the management of furbearers in Alaska are: 1) control of the harvest by regulatory laws, 2) the establishment of refuges, 3) management of the habitat, and 4) management of individual traplines. Although the four approaches to management co-exist and are often interdependent, the management program can be profoundly changed by shifting the emphasis on management from one approach to another.

Control of the Harvest

The primary emphasis in the management of marten and of other furbearers in Alaska has been on regulations which, in most instances, have attempted to control the harvest. Controlling the harvest by regulatory measures nearly always results in a program that lacks the flexibility desirable in maintaining a maximum sustained yield. Regulatory measures are advantageous, however, in that they can be applied in most instances with a minimum of effort and of biological knowledge. Methods by which the harvest are controlled include closed seasons, varied lengths of seasons, harvest quotas or seasonal limits, and restrictions in harvest methods.

Closed Seasons.--Closing of seasons (no period of open season during the year) is a conservative form of regulation designed to prevent further reduction of a population which is at a low density

and to permit recovery. At times, especially when trapping pressure is heavy, closed seasons prove useful, but they should be used cautiously for populations of marten and other furbearers may often fluctuate independently of trapping pressure (see Population Fluctuations). Disadvantages of the use of closed seasons are that they prevent the establishment of a sustained harvest, and encourage excessive trapping pressure in years with open seasons.

In Alaska, closed seasons have usually followed those in which harvest returns have indicated a drop in the population (Table 1). Closed seasons have thus been largely corrective measures rather than preventive ones, and have resulted in longer closures than would have been necessary otherwise. Prediction of low populations, however, may be possible with marten by using annual statistics of the age structure of the population (see Age Ratios). Seasons may be closed so that trapping is eliminated only during the period of low population, thereby resulting in a minimum length of closure.

Length of Season. --Limiting the lengths of open seasons limits the harvest, but unlike the closing of seasons, permits the maintenance of a sustained yield. An advantage of shortening seasons rather than closing them, is that trappers in areas of relatively high populations can continue to harvest surplus animals, while those in areas of low marten densities cannot trap profitably. The larger proportion of males harvested early in the season indicates the value

of a shortened season for the protection of females. Thus, shortened seasons not only reduce the harvest, but may effectively eliminate trapping in low density areas and may tend to preserve the reproductively important females.

Harvest Quotas.--Harvest quotas, like the closed season, are a conservative type of regulation. They are generally not desirable in management of fur animals for they do not allow for differences in population density on individual traplines. An example which shows the disadvantage of harvest quotas is offered by the production figures from two traplines: Al Lycher's on which the average harvest is between 40 and 50 animals, and Antoon Malde's on which the average harvest is about 100 animals. If in a period of low population, a seasonal limit of 30 animals were enforced, as in the season of 1946-1947, Lycher's line might be properly managed by the use of the limit, but Malde's line would probably be underharvested. In addition, Malde could not operate his line profitably unless he were permitted a much larger quota than the 30 animals.

Restrictions on Harvest Methods.--Restrictions on harvest methods in most instances are used to limit the take. They also may provide protection to other species which exist in the same habitat; they may provide protection to home sites of animals being trapped, and may prevent unnecessary waste or loss of fur. These factors are

considered in Alaskan regulations which ban the use of shotgun, artificial light, poison, smoke candles, or chemicals, in the taking of marten.

Refuges

Refuges are established primarily to provide a reservoir population in case trapping in surrounding areas should be excessive, and to provide for restocking or maintenance of the population in surrounding areas by dispersal from the refuge.

It has been shown that dispersal of marten from refuges may significantly affect the populations surrounding the refuge (see Dispersal). The characteristics of this dispersal, the segments of the population involved in it, the distance to which dispersal movements are effective, and the rate at which dispersal takes place, however, have not yet been adequately determined. Selection of refuge areas should depend on this information.

Theoretically, refuges should be large enough to provide complete protection for at least a part of the resident population. The diameter of the refuge must, therefore, be at least twice as large as the total cruising radius of the species with which it is concerned--for the marten, perhaps 10 to 15 miles across, or if only the range of the adult female is considered, 3 to 5 miles, depending on topographic features and food supply.

The effective radius of dispersal from a refuge is equal to

the annual mobility of the species for which it is intended. For marten, the effective radius is probably about 25 to 30 miles. Because young unsettled animals, and possibly adult males, move greater distances than adult females, the effective radius may be greater than the diameter of the refuge.

Maximum benefit is obtained from refuges when dispersal movements from adjacent refuges overlap. Thus, refuges should not be separated by a distance of more than twice that of their effective radius. Because fewer animals are involved in dispersal from small refuges, they may need to be spaced even more closely than is indicated above.

The establishment of a refuge system which would provide a maximum yield for the marten would involve the administrative delineation of such nebulous boundaries that it is prohibitive under present conditions in Alaska. Even those refuges whose purpose is to provide a safeguard against excessive trapping pressure, such as refuges already established in interior Alaska, are of dubious value. Nowhere in interior Alaska is trapping so intensive that it could conceivably threaten the existence of the marten population. The mere economics involved in the harvest would probably stop trapping long before a dangerously low population level was reached. Furthermore numerous, small, untrapped areas exist even in the most heavily trapped areas. These untrapped areas would serve as natural

refuges and provide adequate breeding stock if needed, and would have much more effect on the re-establishment of higher population levels than would the dispersal movements from a few scattered refuges.

Habitat Management

Because spruce forest is the critical element in the marten's habitat, management of the habitat requires the preservation of spruce. Control of forest fires, the most important destructive agent, is already an integral part of the forestry program of the Division of Forestry of the Bureau of Land Management and of the United States Forest Service, and at least in part, provides the necessary management.

Management of Traplines

Management of individual traplines, whether under the present system used in Alaska or under a registered trapline system as used in much of Canada, offers the most effective potential tool in the management of marten. The registered trapline seems superior to other management systems because it offers permanency and security to the trapper, and therefore encourages proper management practices.

An example which stresses the desirability of trapline management is offered by an analysis of the records from four adjacent

traplines in the Minchumina area (Table 8). It has been shown that the proportion of immature marten in the harvest for all of interior Alaska dropped from 56 percent in the 1951-1952 season to only 36 percent in the 1952-1953 season. A similar decrease, although of lesser magnitude (51 percent to 42 percent), can also be shown for the Minchumina area. The decrease in the proportion of immature animals in the harvest, coupled with some evidence of a smaller harvest in 1952-1953, suggests the necessity of harvest restrictions in 1953-1954. When the individual traplines are considered, however, restriction of the harvest seems necessary only on the trapline operated by Antoon Malde on which the harvest dropped from 123 to 44, and the proportion of immature animals in the harvest decreased from 46 percent to 0.0 percent. Restrictions on the harvest at first seem indicated by the 37 percent of immature animals on Carey's line, but because this trapline had not been used for three years, a low proportion of immature animals is to be expected. No lowering of the productivity was indicated on traplines operated by Blackburn and Granroth on which the proportion of immature animals was 67 percent and 52 percent, respectively.

Although statutory refuges are considered impracticable or of slight value under present conditions in interior Alaska, judicious placement of trails on traplines may provide effective sanctuary to a large part of the adult females, and yet permit maximum harvest

of immature animals and adult males. Information is still too limited to permit definite recommendations, but it seems likely that if trails are separated by distances of three to five miles, such a result would be obtained.

Proper management of traplines would involve the gathering and analysis of various biological data by the trapper, and at times would mean voluntary restrictions of the harvest or changes in trapping methods. For example, a decrease in the proportion of immature animals in the take from the normal of 45 percent to about 30 percent could indicate a decline in population caused by an unsuccessful breeding season. The decrease in the proportion of immature animals could also indicate a difference in trapping pressure, or a variation in movements caused by weather or food supply. Observation by the trapper would indicate which. A similar hypothetical example for sex ratio data could be established, i.e. an increase in the number of females in the catch could indicate over-trapping or reduced movements of males caused by weather or food. Again, observation should determine the cause; if over-trapping is responsible, the harvest should be reduced. If the data are analyzed as they accumulate, remedial action can be taken before the population is seriously damaged.

SUMMARY

This investigation of the marten was initiated to obtain information on which to base a sound management policy.

Although the exploitation of fur was later in interior Alaska than in other parts of North America, trapping pressure since the decline of the gold rush has been heavy, at times probably excessive. This effect of trapping on furbearers is indicated in harvest records.

In interior Alaska marten are found in areas of spruce forest upon which they apparently depend. The two major factors controlling the extent and distribution of spruce are topography and fire.

Information relative to the population dynamics of marten was obtained from harvest records, by the examination of pelts in the possession of fur buyers, and by examination of carcasses obtained from trappers. During the season of 1951-1952, 405 pelts and 143 carcasses were examined; in the season of 1952-1953, 641 pelts and 155 carcasses.

Sex was determined from pelts by the presence of the penis scar in males, or by noting the direction underfur grows at the posterior end of the abdominal gland, the direction of growth being reversed at this point in the male.

Sex was most accurately determined from skulls on the basis of total length, those skulls exceeding a length of 82 mm. being males.

Age was most easily determined from skulls by measurement of the sagittal crest. Females with an undeveloped crest, and males with an undeveloped crest and those with a crest of less than 25 mm. are immature animals. The weights of the bacula in males and the sizes of the uteri in females provide reliable checks on the separation of mature from immature animals. No criterion, however, is satisfactory for separating age groups of older animals.

The sex ratio of marten in the harvest of 1951-1952 was 176:100; in the harvest of 1952-1953, 150:100. The greater proportion of males in the harvest is thought to be caused by their greater mobility. The proportion of females in the harvest increased in the latter part of the season and is probably caused by a decrease in the number of males in the population. The sex ratio of immature animals in the harvest was 103:100, and in mature animals was 138:100. The difference is thought to be caused by the restricted movements of the adult females as compared to that of males and juvenile females.

Forty-six percent of 1,553 marten skulls examined by several investigators (the author; DeVos, 1952; Hagmeier, in corr. 1953; Yeager, 1950) were from immature animals. In the harvest of 1951-1952 in Interior Alaska, 56 percent of the animals were immature; in 1952-1953, only 36 percent were immature. The low proportion of immature animals present in the harvest of 1952-1953 was probably caused by an unsuccessful breeding season.

This unsuccessful breeding season seemed to be reflected by a slight decrease in the harvest. It may cause a similar decrease in the harvest three years hence, when the normal recruitment to the breeding population will be lacking.

The opinion of most investigators is that wild marten are polygamous. Marten mate in late June or July and parturition is normally in April. The gestation period is therefore about eight or nine months. The average number of young in litters is approximately three.

Marten do not normally become sexually mature until they are two years old; some individuals, not until they are three years old. Few animals are thought to be unproductive as a result of old age.

Cyclic fluctuations of marten have been described by several authors. These fluctuations may take place independently of trapping, may be modified by trapping, or may even be accentuated by trapping. Harvest regulations in Alaska have largely masked any natural fluctuation which may have occurred.

Information on movements of marten was obtained by following tracks, and by the recapture of tagged animals. Live-trapping operations were conducted at Cassiar from May 10 to 16, 1952, at Castle Rocks from June 26 to July 24 and from August 13 to 30, 1952, and at Murphy Dome from November 13 to 28, 1952.

A total of 1,833 trap units resulted in 25 captures of 15 animals.

Females were recaptured more frequently than males, indicating restriction of their movements to a smaller area than that of males.

Although the marten travels in an erratic manner, a definite hunting route is apparently followed.

Wet weather seems to restrict movements of marten, though snow may increase them. Movements are considerably restricted when temperatures are colder than -25° F.

Marshall (1951) says that the home range of marten in Montana is about 10 to 15 square miles. The limited evidence from Alaska indicates that the home range of Alaskan animals may be comparable in size, the range of females probably being smaller and that of males being as large or larger. When food is abundant movements may be restricted to a smaller area than when food is scarce.

No North American record was found of movements involving mass emigration of marten to a new area. Seasonal migrations, usually altitudinal, are known. Normal dispersal movements, probably primarily of young animals, may involve movements of considerable distances.

In interior Alaska, microtine rodents were found to be the most important food of marten. Birds, primarily grouse in winter and the young of passerines in summer, were common in the diet. Berries are an important food in late summer and fall, the period when they are most available. Squirrels and the varying hare were

relatively uncommon in the diet. Foods accepted by captive animals and the behavior of animals in captivity indicated that food-getting is probably the dominant psychological urge of marten.

Management of the marten may be by use of regulatory statutes, by management of the habitat, and by management of individual traplines.

Management by regulatory measures usually involves control of the harvest; these controls often prove unnecessarily restrictive. Limiting the length of the season seems the best method of harvest control for it not only limits the harvest but furnishes protection to adult females, the most important segment of the breeding population

Statutory refuges are considered impracticable and probably unnecessary under present conditions in interior Alaska.

Management of the habitat involves preservation of the spruce forest.

Management of traplines seems the most desirable form of management. Although marten populations may fluctuate over large areas, individual traplines, if properly managed, may be relatively unaffected by the general trend, and a sustained yield may be maintained. Although trapline management involves the gathering and application of various biological data, trappers are believed capable of managing their own lines if given incentive and instruction.

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